THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

N. H. WINCHELL, STATE GEOLOGIST.

BULLETIN NO. 1.

THE HISTORY

OF

GEOLOGICAL SURVEYS

IN MINNESOTA.

From

BY N. H. WINCHELL.

ST. PAUL:
THE PIONEER PRESS COMPANY.
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The first effort of the State of Minnesota to institute a survey of her domain was made in 1858 by the first Legislature that met after the admission of the state into the Union. No general law was passed, but a reprint was ordered of a portion of former reports by Prof. Daniels on the survey of Wisconsin, in which state Minnesota had then latterly been embraced.

The commissioner of statistics, Joseph A. Wheelock, also included in his official reports for the years 1859 and 1860, general summaries of the physical features and agricultural capabilities of the state, which went far toward recommending the state to eastern immigrants. The facts, however, were derived not so much from original observation as from newspaper articles, reviews and correspondence. These reports were widely distributed and introduced the state, in its diversified natural resources, favorably, to the rest of the Union, which undoubtedly was the prime object of their author.

An abortive attempt to establish a regular geological survey was made by the second State Legislature, which adopted a "concurrent resolution" ordering the appointment of commissioners to report on the geology of the state, and on a plan for a geological survey. These commissioners made separate reports, setting forth the utility of such a survey, but owing to the financial burdens which the young state had to bear, incident to the inauguration of the various public institutions, and to the opposition of governor Ramsey, the Legislature did not take any further action upon the subject.

The Legislature of 1864, however, by joint resolution, authorized the governor to appoint and direct a state geologist. The appointee was Dr. Aug. H. Hanchett, and he associated with himself Mr. Thomas Clark, who had been one of the "commissioners" of the resolution of 1860. These gentlemen each made one report for 1864, that of Mr. Clark containing some valuable information concerning the physical features of the northern

part of the state, but adding little or nothing to the actual geology. For a report of progress, on the first year's work, limited in time and means, the pamphlet containing these two papers may be considered a creditable production; and had the survey been continued as planned by Mr. Clark it might have become useful and successful. But it became apparent that Dr. Hanchett was not intelligently and wholly devoted to the work, and on the passage of a more general act by the Legislature of 1865, the governor conferred the position of state geologist upon Mr. Henry H. Eames.

Mr. Eames made two brief annual reports of progress, one for 1865 and one for 1866. The former is devoted to an account of a "prospecting" tour made by him through the metalliferous region bordering on lake Superior, and the latter to observations on the geology of some of the north central counties of the state. It was owing to the discoveries of Mr. Eames that the "gold fever" centering on Vermilion lake rose in speculative mining circles. This prevailed for about two years, and subsided after the Legislature refused further appropriations for the survey.

The notes and observations of Col. Charles Whittlesey, made in Minnesota at various times, sometimes for parties at private expense and sometimes for the United States government, were printed at the cost of the State of Minnesota, and issued, at Cleveland, Ohio, as a "Report of explorations in the mineral regions of Minnesota during the years 1848, 1859 and 1864," dated 1866. As a geological report this unpretentious brochure is of more value than all the previous reports, issued under the auspices of the state, combined.

In 1865 Mr. N. C. D. Taylor was authorized by act of the Legislature to make surveys for copper in the valley of the St. Croix and of the Kettle rivers, to the aggregate cost of one thousand dollars. A brief report, occupying about one octavo page, was rendered by Mr. Taylor and printed in the executive documents (for 1866?), giving an account of his operations and quoting the verbal opinion of Prof. James Hall.

In 1870 Prof. A. Winchell was appointed by the governor to examine and report on the reputed salt springs at Belle Plaine, with a view to ascertain the propriety of appropriating money to aid in the development of the brine by the State Legislature. The published report is an octavo pamphlet of sixteen pages, and was the last work of the kind done through the instrumentality of the state before the beginning of the present survey.

Those who desire a fuller account of these early surveys and of other similar work in the State of Minnesota, prior to 1872, may consult the final report of the present "geological and natural history survey," Vol. I. It is the purpose of this paper to deal more fully with the progress and history of the present survey.

History of the Geological and Natural History survey of Minnesota.

The law which organized this survey was drawn up by president Wm. W. Folwell, of the University of Minnesota. This law, before it was offered in the State Legislature, was shown to some geologists and educators, who might have some opinion or advice to offer as to its provisions. There is no question but one of the prime motives of the law was to introduce another auxiliary force into the state university by making it the centre whence should radiate information concerning the natural features of the state, and toward which should gravitate all collections of natural history that should otherwise be brought to light. It would furnish information, perhaps to the body of students through its officers, to the state at large, and to the country, through its reports; and in its museum would be seen the outward proofs of the resources of the state and the means for illustrating the natural sciences as they should be taught in the university. The actual and minute study of the natural history of the state was, perhaps, a secondary motive, although this is specifically required by the terms of the law. It is a comprehensive law, and was introduced into the state Senate by regent J. S. Pillsbury. Having passed both houses, it was approved by governor Horace Austin, March 1, 1872. It reads as follows:

Law of the Minnesota survey.

An act to provide for a geological and natural history survey of the state and to entrust the same to the University of Minnesota.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. It shall be the duty of the board of regents of the University of Minnesota to cause to be begun as soon as may be practicable, and to carry on a thorough geological and natural history survey of the state.

SEC. 2. The geological survey shall be carried on with a view to a complete account of the mineral kingdom as represented in the state, including the number, order, dip and magnitude of the several geological strata, their richness in ores, coals, clays, peats, salines and mineral waters, marls, cements, building stones and other useful materials, the value of said substances fo economical purposes and their accessibility; also an accurate chemical analysis of the various rocks, soils, ores, clays, peats, marls and other mineral substances, of which complete and exact records shall be made.

SEC. 3. The natural history survey shall include, first, an examination of the vegetable productions of the state, embracing all trees, shrubs, herbs and grasses native or naturalized in the state; second, a complete and scientific account of the animal kingdom as properly represented in the state, including all mammalia, fishes, reptiles, birds and insects.

SEC. 4. The said surveys and examinations shall be made in the manner and order following: First, the geological survey proper, together with the necessary and implied mineralogical investigations, all of which shall be undertaken as soon as may be practicable, and be carried forward with such expedition as may be consistent with economy and thoroughness; second, the botanical examinations; third, the zoological investigations; provided, however, that whenever the said board of regents may find it most economical to prosecute different portions of the surveys in conjunction, or that the public interest demands it, they may, in their discretion, depart from the above prescribed order. And in the employment of assistants, in the said surveys the board of regents shall at all times give the preference to the students and graduates of the University of Minnesota, provided the same be well qualified for the duties.

SEC. 5. The said board of regents shall also cause to be collected and tabulated such meterological statistics as may be needed to account for the variety of climate in the various parts of the state; also to cause to be ascertained [by] barometrical observations or other appropriate means the relative elevations and depressions of the different parts of the state; and also on or before the completion of the said surveys, to cause to be compiled from such actual surveys and measurements as may be necessary, an accurate map of the state, which map when approved by the governor shall be the official map of the state.

SEC. 6. It shall be the duty of said board of regents to cause proper specimens, skillfully prepared, secured and labeled, of all rocks, soils, ores, coals, fossils, cements, building stones, plants, woods, skins and skeletons of animals, birds, insects and fishes, and other mineral, vegetable and animal substances and organisms discovered or examined in the course of said surveys, to be preserved for public inspection, free of cost, in the University of Minnesota, in rooms convenient of access and properly warmed, lighted, ventilated and furnished, and in charge of a proper scientific curator; and they shall also, whenever the same may be practicable, cause duplicates in reasonable numbers and quantities of the above named specimens, to be collected and preserved for the purpose of exchanges with other state universities and scientific institutions, of which latter the Smithsonian Institution at Washington shall have the preference.

SEC. 7. The said board of regents shall cause a geological map of the state to be made, as soon as may be practicable, upon which, by colors and other appropriate means and devices, the various geological formations shall be represented.

SEC. 8. It shall be the duty of the said board of regents, through their president, to make, on or before the second Tuesday in December of each and every year, a report showing the progress of the said surveys, accompanied by such maps, drawings and specifications as may be necessary and proper to exemplify the same to the governor, who shall lay the same before the Legislature ; and the said board of regents upon the completion of any separate portion of the said surveys, shall cause to be prepared a memoir or final report, which

shall embody in a convenient manner all useful and important information accumulated in the course of the investigation of the particular department or portion, which report or memoir shall likewise be communicated through the governor to the Legislature.

SEC. 9. To carry out the provisions of this act the sum of one thousand dollars per annum is hereby appropriated, to be drawn and expended by the [said] board of regents of the University of Minnesota.

SEC. 10. This act shall take effect and be in force from and after its approval.

Approved March 1, 1872.

This is the organic law of the survey, and it is still in force in all its provisions. The Legislature, in some of its subsequent sessions, passed laws to facilitate the execution of this, or amplifying some of its provisions, but in no respect has a single clause of this law been abrogated or restricted.

Although the law was passed and approved on the first day of March, the regents took no action looking to its execution till July following, when the writer was summoned to St. Paul from active field work in the State of Ohio to meet the board of regents then in session, and to assume the position of state geologist under the law. Engagements in Ohio, however, would not permit the beginning of the season's work till September.

A moment's examination of the law was sufficient to convince any geologist that the sum of money appropriated for the work was wholly inadequate to the purposes which the law contemplated; and therein it is evident that the Legislature did not so much expect the law would effect a complete survey of the state as that it would pay, in a measure, the services of an officer at the university who should be made useful in any way that the regents could find it convenient to have him work, giving particular attention to the natural sciences. The survey in this position had not an encouraging outlook, and the appointment to its head implied that the man who accepted it would either fail ignominiously or must find some way to increase the revenues that were vital to its continuance and its success. It was in view of this that the first annual report closed with the following recommendation:

Recommendations concerning the Salt Spring lands.

The law under which the present survey is being prosecuted appropriates the sum of one thousand dollars per annum. This is too small, for various reasons, the chief of which are:

First — It will not pay for the services of a single employé on the survey capable of working under the law. Hence, it well-nigh renders the law inoperative.

Second — It does not command the respect and confidence of the citizens of the state and others, and serves as an excuse for refusing aid and co-operation. The survey should be independent of favors for which it now has to beg, sometimes to be scornfully rebuffed.

Third — In the survey of those portions of the state inaccessible by public roads, or by railroads, it will be necessary to employ laborers, and incur other expense, for which the sum of one thousand dollars is not sufficient.

Fourth — In order to conduct the survey on one thousand dollars per annum, the state geologist must find some other employment a portion of the year.

Fifth — The magnitude of the interests involved demands that ample means be allowed for doing the work of the survey thoroughly and without embarassment.

These considerations ought to induce the legislature to increase the amount now appropriated to a sum sufficient at least to keep one man constantly employed, and to pay all expense of field-work and chemical examinations.

In connection with the subject of increasing the means provided for the geological survey, it is suggested that the state lands known as *salt lands* may be so sold or appropriated, under the management of the board of regents of the university, as to be available for that purpose. It would be in perfect consonance with the original design in the reservation of those lands from sale, if they were placed in the custody of the board of regents, conditioned on their use in the prosecution of the geological and natural history survey of the state.

The law cannot be carried out without the purchase of chemicals and apparatus for the use of the chemical department of the survey, and without the purchase of instruments to be used in the prosecution of the field-work. It is too much to ask the state university, which now pays the services of the chemist of the survey, besides furnishing rooms for laboratory work, to provide for these expenses. There ought to be a special appropriation of several hundred dollars to make these purchases. The board of regents are referred to the accompanying statement of Prof. D. P. Strange, chemist of the survey, for information on this subject.

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In the prosecution of the geological survey proper, after a general reconnoissance, with a view to the determination of the general trend of the formations, and the identification of sufficient characters to decide their ages, it will be necessary to enter on the detailed examination of the state by counties. This more special investigation implies the careful delineation of the outlines of the formations, with all their windings, as they are found in each county, together with a scientific account of the chemical and mineralogical characters of the rocks found therein. In the progress of the survey the specific names of the fossils pertaining to the various formations will be ascertained, and in the end complete lists of these ancient faunas will be made out, to which will be added descriptions and figures to illustrate any new species that may be discovered. These investigations necessarily require much time and study, to say nothing of the labor of collecting and preserving the specimens.

The question of the existence of brine in Minnesota, is one of the most important, in an economical sense, that can be presented for the investigation

of the survey. It should not be hastily answered. Too much is involved to be vested on the result of a guess. Too much, also, is involved to be prejudiced by the failure of unguided expenditures. The tests that may be made ought to be made in the fullest light of all the facts that science, with its generalizations, can throw upon them. It comes within the scope of geological investigation, and ought not to be hazarded in the hands of empirical novices.

The salt springs said to occur in the state may have either of two origins. They may be the result of overflow of extensive salt basins, embraced in the rocky structure of the state, or they may be the result of superficial accumulations similar to the other saline and alkaline deposits that are scattered largely over the western plains. It is not intended now to give this question the discussion its importance demands at the hands of the survey. No investigation of the phenomena of the regions where these springs exist has been made. It is only intended to suggest the importance of correct scientific processes in the future efforts for their development.

It was fortunate for the survey that at this juncture the public had become convinced, pretty generally, that the legislative aid that had been sought by the Belle Plaine salt company, and had been granted by the donation of some of the Salt Spring lands of the state, even contrary to the recommendation of the geologist who had advised against it, was a scheme to make inroads on the Salt Spring lands, more than for the *bona fide* exploitation of the brine springs that were said to exist at Belle Plaine. It was evident that unless some other use were made of this United States land-grant other enterprising communities, or mining companies, would discover salt water, or some other reasons for making inroads on this grant for aid in "developing" such suspected natural wealth. Indeed, the present writer was hardly known to have been appointed state geologist before he was requested to accompany the officers of the Belle Plaine salt company to some other part of the state in order to designate where the next deep well should be sunk for finding brine, at the expense of the Salt Spring lands. Several far-seeing public officers, it seems, at about the same time, suggested that these lands should be saved for some better purpose. Among those who had thus conferred, and had concluded that these lands might be appropriated to the maintenance of the geological and natural history survey of the state, should be mentioned Hon. A. J. Edgerton,* then state railroad commissioner, Hon. H. B. Wilson, superintendent of public instruction, Hon. O. B. Whitcomb, state auditor, and Senator J. S. Pillsbury, one of the regents of the university. From none of these, however, did the suggestion first come to the writer, but from Mr. W. D. Hurlbut of Rochester,

*Since United States Senator from Minnesota and Chief Justice of Dakota.

and it was almost solely through his representations that the following rough draft of a law was prepared by the state geologist, and forwarded to Hon. J. S. Pillsbury with a request that he would re-model it according to his judgment, and offer it in the state Senate the following winter. Mr. Pillsbury, however, turned it over to senator Edmund Rice of St. Paul, who introduced it *verbatim* as drafted, and it so passed both houses and was approved by the governor.

The appropriation of the Salt Spring lands.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. The state lands known as *state salt lands*, donated by the general government to aid in the development of the brines in the State of Minnesota, shall be transferred to the custody and control of the board of regents of the University of Minnesota. By said board of regents these lands may be sold in such manner, or in such amounts, consistent with the laws of the State of Minnesota, as they may see fit; the proceeds thereof being held in trust by them, and only disbursed in accordance with the law ordering a geological and natural history survey of the state.

SEC. 2. It shall be the duty of the said board of regents, as soon as practicable, to cause a full and scientific investigation, and report on the salt springs of the state, with a view to the early development of such brine deposits as may exist within the state.

SCE. 3. The board of regents of the university shall cause the immediate survey and investigation of the peat deposits of the State of Minnesota, accompanied by such tests and chemical examinations as may be necessary to show their economical value, and their usefulness for the purpose of common fuel; a full report thereon to be presented to the Legislature as soon as practicable.

SEC. 4. The sum of two thousand dollars is hereby appropriated annually (in lieu of one thousand dollars) for the purpose of the geological and natural history survey until such time as the proceeds of the sales of the salt lands shall equal that amount, when such annual appropriation shall cease.

SEC. 5. The sum of five hundred dollars is hereby appropriated for the purchase of apparatus and chemicals for the use of the geological and natural history survey, the same to be expended by the order of the board of regents of the University of Minnesota.

SEC. 6. It shall be the duty of the board of regents of the University of Minnesota to cause duplicate geological specimens to be collected, and to furnish to each of the Normal Schools suites of such specimens after the university collection has become complete.

SEC. 7. When the geological and natural history survey of the state shall have been completed, the final report on the same by the said board of regents shall give a full statement of the sales of the salt lands hereby given into the custody and control of the board of regents of the University of Minnesota, together with the amount of moneys received therefrom, and of the balance, if any, left in the hands of said board of regents.

SEC. 8. This act shall take effect and be in force from and after its passage.

Approved March 10, 1873.

It is reasonable to suppose that after the passage of this law all private schemes for the development of doubtful salt springs, and the reduction of the fund by misguided attempts at exploration would cease, but that was not the case. A bill was introduced in the House of Representatives at the next session of the Legislature to grant the Belle Plaine salt company more land in aid of their enterprise, requiring the board of regents to give up to that company a certain amount of the salt spring lands for every one hundred feet deeper that company should sink their well at Belle Plaine, aggregating six sections of land in all. It was duly referred to the proper committee, but was never reported for consideration by the House.

Deficit in the Salt Spring lands.

The Salt Spring lands originally granted the state aggregated 46,080 acres. But by various losses and state grants, and by conflicts with other United States grants, the selections made by the state not having been duly certified and recovered from the available public domain, the amount that was found capable of being used for the survey was only 18,771 acres. The officers of the United States government solely were responsible for this deficit, since governor Sibley, the first governor of the state, had complied with the law and all the terms of the grant, in having them selected.* When this fact was represented to the state Legislature a memorial was passed, addressed to Congress, asking the privilege of making re-selections of land in the state of Minnesota sufficient to make the entire grant good to the State; such permission was granted, and twenty-four sections were added to the available land-grant of the geological survey. These, however, were not turned over to the regents for this purpose till the winter of 1885, when the Legislature passed the following:

AN ACT to transfer to the custody and control of the board of regents of the University of Minnesota the lands granted by Congress to the State by an act entitled "An act granting lands to the State of Minnesota in lieu of certain lands heretofore granted to said State," approved March third (3d), one thousand eight hundred and seventy-nine (1879) to authorize the said board to sell such lands and dispose of the proceeds of such sales.

WHEREAS, The state lands known as state salt lands, were by an act approved March tenth (10), one thousand eight hundred and seventy-three (1873), chapter one hundred and thirty-three (133), general laws of one thousand eight

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* Compare *Miscellaneous Publications* of the survey: Report on the Salt Spring lands due the State of Minnesota; a history of all official transactions relating to them, and a statement of their amount and location. N. H. Winchell, 1874.

hundred and seventy-three (1873), transferred to the custody and control of the board of regents of the University of Minnesota, to be by said regents sold, and the proceeds thereof held in trust by them, and disbursed in accordance with the law ordering a geological and natural history survey of the State; and

WHEREAS, It was found that certain parcels of such state lands had been otherwise disposed of by the United States to actual settlers upon such lands, for which indemnity lands have since been granted to the State by an act of Congress approved March third (3), one thousand eight hundred and seventy-nine (1879); therefore

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. That the lands granted by Congress to this State by an act entitled "An act granting lands to the State of Minnesota in lieu of certain lands heretofore granted to said state," approved March third (3), one thousand eight hundred and seventy-nine (1879), be and the same are hereby transferred to the custody and control of the board of regents of the University of Minnesota, which lands the said board may sell in such amounts as they may deem most expedient and beneficial, the proceeds thereof being held in trust by them, and only disbursed in accordance with the law ordering a geological and natural history survey of the State, and the said board shall make report of their doings in the premises, as provided by law.

SEC. 2. This act shall take effect and be in force from and after its passage.

Approved Feb. 24, 1885.

Publication of the annual reports.

The Legislature of 1876 passed the following law relating to the printing of the annual reports of progress of the survey:

AN ACT relating to the printing of the reports of the board of regents of the University of Minnesota on the progress of the geological and natural history survey of the State.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. One thousand copies of that portion of the annual report of the board of regents of the University of Minnesota which embraces the report of the state geologist on the progress of the geological and natural history survey of the State shall hereafter be paged and bound separately and shall be subject to the disposition of the said board of regents.

SEC. 2. Whenever in the progress of said survey a full and final report shall be made on the geology of any of the counties of the State, five hundred extra copies of each county report so made by the board of regents shall be printed for the use of the counties so reported on; said copies being subject to the order of the county commissioners of said county.

This act shall take effect and be in force from and after its passage.

Approved March 6, 1876.

The annual reports are transmitted to the governor by the regents of the university as a part of their report on the affairs of the university, and they are published as such; and the ex-

pense is provided for regularly by the *printing commission* who make estimates, in advance, of the amount of money needed for all the public printing, reporting the same to the Legislature for appropriation for the current or coming year. Of these reports sixteen have been published, one for each year since the survey began.

Publications of the Geological and Natural History Survey of Minnesota.

THE FIRST ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1872. 112 pp., 8 vo.; with a colored geological map of the State. By *N. H. Winchell.* Contains a list of earlier publications relating to the geology and geography of Minnesota, and a sketch of the geology of the State as known in 1872. Second edition identical with the original, 1884.

THE SECOND ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1873. 145 pp., 8 vo.; with illustrations. By *N. H. Winchell* and *S. F. Peckham.*

THE THIRD ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1874. 42 pp., 8 vo.; with two county maps. By *N. H. Winchell.*

THE FOURTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1875. 162 pp., 8 vo.; with four county maps and a number of other illustrations. By *N. H. Winchell,* assisted by *M. W. Harrington.*

THE FIFTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1876. 248 pp., 8vo.; four colored maps and several other illustrations. By *N. H. Winchell,* with reports on Chemistry by *S. F. Peckham,* Ornithology by *P. L. Hatch,* Entomology by *Allen Whitman,* and on Fungi by *A. E. Johnson.*

THE SIXTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1877. 226 pp. 8vo.; three geological maps and several other illustrations. By *N. H. Winchell,* with reports on Chemical Analysis by *S. F. Peckham,* on Ornithology by *P. L. Hatch,* on Entomology by *Allen Whitman,* and on Geology of Rice county by *L. B. Sperry.*

THE SEVENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1878. 123 pp., 8vo.; with twenty-one plates. By *N. H. Winchell,* with a field report by *C. W. Hall,* Chemical Analyses by *S. F. Peckham,* Ornithology by *P. L. Hatch,* a list of the plants of the north shore of lake Superior by *B. Juni,* and an Appendix by *C. L. Herrick* on the Microscopic Entomostraca of Minnesota (twenty-one plates).

THE EIGHTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1879. 183 pp., 8vo.; one plate (Castoroides). By *N. H. Winchell.* Containing a statement of the methods of Microscopic Lithology, a discussion of the Cupriferous Series

in Minnesota, and descriptions of new species of brachiopoda from the Trenton and Hudson River formations; with reports on the Geology of Central and Western Minnesota, by *Warren Upham;* on the lake Superior region, by *C. W. Hall;* lists of Birds and of Plants from Lake Superior, by *Thomas S. Roberts;* Chemical Analyses by *S. F. Peckham;* report by *P. L. Hatch;* and four Appendixes.

THE NINTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1880. 392 pp., 8 vo.; three appendixes, two wood cut illustrations, and six plates. By *N. H. Winchell.* Containing field descriptions of 442 crystalline rock samples, and notes on their geological relations, from the northern part of the state; new brachiopoda; the water supply of the Red River Valley, and simple tests of the qualities of water; with reports on the Upper Mississippi region, by *O. E. Garrison;* on the Hydrology of Minnesota, by *C. M. Terry;* on the Glacial Drift and its Terminal Moraines, by *Warren Upham;* Chemical Analyses by *J. A. Dodge;* a list of the Birds of Minnesota, by *P. L. Hatch;* and of the Winter Birds, by *Thomas S. Roberts.*

THE TENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1881. 254 pp., 8 vo.; with ten wood cut illustrations, and fifteen plates. By *N. H. Winchell.* Containing field descriptions of about 400 rock samples, and notes on their geological relation, continued from the last report; the Potsdam sandstone; typical thin sections of the rocks of the Cupriferous Series; and the deep well at the "C" Washburn mill, Minneapolis; with Geological notes by *J. H. Kloos;* Chemical Analyses by *J. A. Dodge;* and papers on the Crustacea of the fresh waters of Minnesota (eleven plates), by *C. L. Herrick.*

THE ELEVENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1882. 219 pp., 8 vo.; with three wood cut illustrations and one plate. By *N. H. Winchell.* Containing a report on the Mineralogy of Minnesota, and a note on the Age of the rocks of the Mesabi and Vermilion iron districts; with papers on the Crystalline rocks of Minnesota, by *A. Streng* and *J. H. Kloos;* on Rock outcrops in Central Minnesota, and on lake Agassiz, by *Warren Upham;* on the Iron region of Northern Minnesota, by *Albert H. Chester;* Chemical Analyses by *J. A. Dodge;* and an Appendix containing Minnesota Laws relating to Mines and Mining, abstracted by *C. L. Herrick.*

THE TWELFTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1884. Summary report, containing palæontological notes, and a paper on the comparative strength of Minnesota and New England granites, 26 pages, by *N. H. Winchell;* final report on the Crustacea of Minnesota included in the orders Cladocera and Copepoda. 192 pages and 30 plates, by *C. L. Herrick,* and a catalogue of the flora of Minnesota, 193 pages, with ore map showing the forest distribution, by *Warren Upham.*

THE THIRTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1884. 196 pages. Geological reconnoisances, the Vermilion iron ores, the crystalline rocks of Minnesota, and of the Northwest, the Humbolt salt well in Kittson county, records of various deep wells in the State, fossils from the red

quartzyte at Pipestone, reports on the New Orleans Exposition and on the General Museum, by *N. H. Winchell;* Geology of Minnehaha county, Dakota, by *Warren Upham;* Chemical report by *Prof. James A. Dodge;* Minnesota geographical names derived from the Dakota language by *Prof. A W. Williamson;* insects injurious to the cabbage, by *O. W. Oestlund;* Geological notes in Blue Earth county, by *Prof. A. F. Bechdolt,* and on a fossil elephant from Stockton by *Prof. John Holzinger;* papers on the Cretaceous fossils in the boulder clays in the Northwest by *George M. Dawson,* and by *Woodward* and *Thomas,* and notes on the Mammals of Big Stone Lake and vicinity by *C. L. Herrick.*

THE FOURTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1885. 354 pp.; two plates of fossils and two wood cuts. Containing summary report, notes on some deep wells in Minnesota, descriptions of four new species of fossils, a supposed natural alloy of copper and silver from the north shore of lake Superior, and revision of the stratigraphy of the Cambrian in Minnesota, with the following papers by assistants, viz.: List of the Aphididæ of Minnesota, with descriptions of some new species, by *O. W. Oestlund;* Report on the Lower Silurian Bryozoa, with preliminary descriptions of some new species, by *E. O. Ulrich;* Conchological notes by *U. S. Grant;* Bibliography of the Foraminifera, recent and fossil, by *Anthony Woodward.*

THE FIFTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1886. 493 pp., 8vo.; 120 diagram illustrations and sketches in the text, and two colored maps; embracing reports on observations on the crystalline rocks in the northeastern part of the state, by *Alexander Winchell, N. H. Winchell and H. V. Winchell;* Chemical report by *Prof. J. A. Dodge;* additional railroad elevation, by *N. H. Winchell;* list of Minnesota geographical names derived from the Chippewa language, by *Rev. J. A. Gilfillan,* and notes on Illæni, describing three new species, by *Aug. F. Foerste.*

THE SIXTEENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1887. 504 pp.; two plates, one map and eighty-eight other illustrations. Contains observations in the area of the original Huronian by the state geologist and by *Alexander Winchell;* also on the Marquette, the Gogebic and the Penokee iron regions; also reports on further observations in the northeastern part of the State, by the same; also a report by *Horace V. Winchell* on the region of the Big Fork and Little Fork rivers, and Rainy lake; also notes on the molluscan fauna of the state by *Uly S. Grant* and *John M. Holzinger.*

The publication of the Final Report.

The Legislature of 1885 also made provision for the publication of the final report of the survey by the enactment of the following general law.

AN ACT relating to the publication of the report of the geological and natural history survey of the State.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. The governor, the secretary of state and the state geologist are hereby created a commission for the printing and publication of the reports of the regents of the university on the geological and natural history survey of the State.

SEC. 2. It shall be their duty to supervise the printing of the final reports of said survey, and the engraving of the accompanying maps and illustrations, in such style and manner as they shall determine and judge best calculated to exhibit to the people of the State, the natural resources of the State as required by the law creating the geological and natural history survey.

SEC. 3. They shall cause to be republished in the same manner the third (3d), fourth (4th) and fifth (5th) reports of progress of said survey, at as early a date as practicable, in an edition of two thousand copies.

SEC. 4. The volumes of the final report of said survey, as they may be prepared by the state geologist from time to time, shall be issued in an edition of five thousand (5,000) copies each, and shall be distributed, in the name of the board of regents of the university, under the direction of the state geologist, to scientific and educational institutions, and to individuals, as follows: To the library of each chartered college and scientific institution in Minnesota, three (3) copies each; to each normal school, three (3) copies; to the libraries of the institute for the deaf and mute, the insane asylums, the state prison, and every public library in the state not otherwise designated, one (1) copy each; to each of the offices in the capitol, one (1) copy; to each member of the board of regents, three (3) copies; to the library of the state university two hundred (200) copies; to the Historical Society, and to the Minnesota academy of sciences, ten (10) copies each; to each newspaper published in the State, one (1) copy each; to each senator and representative of the present Legislature, one (1) copy; to the governor and lieutenant governor, each one (1) copy; to each assistant on the survey who has furnished manuscript or illustrations published in the report, three (3) copies; to the general office of each railroad that has furnished aid to the survey, three copies; to the library of each high school, furnishing students fitted for the freshman class of the state university, one (1) copy; to the state library of each state in the Union, one (1) copy; to each state university and each college of agriculture and mechanic arts, one (1) copy; to geologists and naturalists of Minnesota, fifty (50) copies; to the geologists and naturalists of other states, two hundred (200) copies; to other colleges and scientific institutions in the United States, one hundred (100) copies; to foreign institutions and scientists, one hundred (100) copies; and to the state geologist, twenty-five (25) copies. The remainder shall be deposited in the state university, and shall be sold at such prices as the board of regents may determine, and the proceeds of

such sales shall be used by said regents for the purchase of apparatus and books for the survey, and after its completion, for the departments of natural science at the state university.

SEC. 5. The expense of printing, engraving, binding and distribution of said reports shall be paid out of any moneys not otherwise appropriated, in the state treasury, on warrants of the state auditor approved by the governor and secretary of state.

SEC. 6. The commissioners hereby appointed shall perform the duties herein designated without further compensation than the payment of the actual expenses incurred in the discharge thereof.

SEC. 7. This act shall take effect and be in force from and after its passage.

Approved March 7, 1885.

Before this law took effect the first volume of the final report had been printed and the second was well under way of publication. The final report is ordered by the same law that orders the annual reports, and every provision that can be construed for the publication of the latter is binding for the former. This view was held by the standing printing commission, and when the regents tendered Vol. I. of the final report the secretary of state gave orders for its publication as one of the documents of the state. Still, inasmuch as there might be a difference of opinion as to the binding obligation on the proper officers to make provision for the final report, it was declared in the foregoing law that such volumes *shall be issued and shall be distributed* and that *the expense of printing, engraving, and distribution shall be paid out of any moneys not otherwise appropriated in the state treasury.* Thus the publication of the results of the survey is made a regulated function of the printing bureau of the state, and can no more be omitted, in the plans for publishing the documents of the state, without neglect of duty, than can any others of the state documents which by law are required to be presented to the governor.

In accordance with this law the same Legislature appropriated twelve thousand dollars intended to cover the expense of publishing volumes II. and III. of the final report. But, by a curious proviso such as sometimes creep into laws passed in the hurried manner of modern American legislation, this fund was required to be expended by the regular commissioners of printing, and not by the special commission which was created for the publication of the final report. The appropriation was found to be but little more than sufficient for publishing one of the volumes (Vol. II.), and that was issued in the fall of 1888. The final report of the survey, so far as published, is described as follows:

THE GEOLOGY OF MINNESOTA. VOL. I. OF THE FINAL REPORT. 1872-1882. xiv. and 697 pp., quarto; illustrated by 43 plates and 52 figures. By *N. H. Winchell*, assisted by *Warren Upham*. Containing an historical sketch of explorations and surveys in Minnesota, the general physical features of the state, the building stones, and the Geology of Houston, Winona, Fillmore, Mower, Freeborn, Pipestone, Rock and Rice counties, by *N. H. Winchell;* the Geology of Olmsted, Dodge and Steele counties, by *M. W. Harrington;* and the Geology of Waseca, Blue Earth, Faribault, Watonwan, Martin, Cottonwood, Jackson, Murray, Nobles, Brown, Redwood, Yellow Medicine, Lyon, Lincoln, Big Stone, Lac qui Parle and Le Sueur counties, by *Warren Upham*. Distributed gratuitously to all public libraries and county auditors' offices in the state, to other state libraries and state universities, and to leading geologists and scientific societies; the remainder are held for sale at the cost of publication, \$3.50 per copy in cloth, or \$5 in grained half roan binding upon application to Prof. N. H. Winchell, Minneapolis.

THE GEOLOGY OF MINNESOTA. VOL. II. OF THE FINAL REPORT. 1882-1885. xxiv. and 695 pp., quarto; illustrated by 42 plates and 32 figures. By *N. H. Winchell*, assisted by *Warren Upham*, containing chapters on the Geology of Wabasha, Goodhue, Dakota, Hennepin, Ramsey and Washington counties, by *N. H. Winchell*, and on Carver, Scott, Sibley, Nicollet, McLeod, Renville, Swift, Chippewa, Kandiyohi, Meeker, Wright, Chisago, Isanti, Anoka, Benton, Sherburne, Stearns, Douglas, Pope, Grant, Stevens, Wilkin, Traverse, Otter Tail, Wadena, Todd, Crow Wing, Morrison, Mille Lacs, Kanabec, Pine, Becker and Clay counties, by *Warren Upham*. Distributed according to law in the same manner as Vol. I. above.

The Bulletins of the Survey.

The Legislature of 1885 enacted the following law, requiring the state geologist to make actual explorations by drilling or digging, for the discovery of economic products, and providing for the publication of the reports of such discoveries, and of other scientific contributions:

AN ACT to extend the work of the geological and natural history survey of the State.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. It shall be the duty of the state geologist, to make practical and actual tests by drilling or digging or other excavation in the earth, such as he shall deem best suited to accomplish the purpose of this bill, for the discovery of any of the hidden mineral resources of the state, such as iron, copper, silver, gold, coal, gas, coal-oil, common salt, or any other valuable material that he may deem likely to exist in any of the rock strata of the state.

SEC. 2. In determining the localities at which such testing and exploring shall be done he shall be guided by such geological facts as he may possess or may obtain, which may indicate the existence of any of the substances which it is the purpose of this act to discover. He shall also be guided by the proportionate amount of money that the owner, or owners, of the land on which such exploration may be proposed, shall contribute to pay the cost of such exploration.

SEC. 3. It shall be the duty of the state geologist to report at once to the board of regents all discoveries, either of economic or scientific interest to the state, that may be made by such testing and exploration. Such report shall be published by the board of regents in the same manner as now provided for the publication of the annual reports of the geological and natural history survey of the state, and shall be paid for by the same fund; *provided*, that any important mineral discoveries, or other scientific contributions to the geological and natural history survey, that the said state geologist may deem necessary for immediate publication, shall not be suppressed until the regular report of the board of regents, but shall be issued from time to time under the direction of said state geologist.

SEC. 4. That the sum of five thousand (5,000) dollars for the year A. D. one thousand eight hundred and eighty-seven (1887) and the sum of five thousand (5,000) dollars for the year A. D. one thousand eight hundred and eighty-eight (1888) is hereby appropriated out of any moneys not otherwise appropriated for the purpose of defraying the expense of said tests. The investigations provided for in this act shall not be conducted in the interest of any mining company or corporation.

SEC. 5. This act shall take effect and be in force from and after its passage.

Approved March 8th, 1887.

In accordance with this law it was deemed best to establish a series of minor publications or "bulletins," which might be issued from time to time, at longer or shorter intervals, and the following have appeared:

BULLETINS.

No. 1. History of Geological Surveys in Minnesota. By *N. H. Winchell.*

No. 2. Preliminary Description of the Peridotytes, Gabbros, Diabases and Andesytes of Minnesota. By *M. E. Wadsworth.*

No. 3. Report of work done in Botany in the year 1886. By *J. C. Arthur.*

No. 4. A Synopsis of the Aphididæ of Minnesota. By *O. W. Oestlund.*

No. 5. Natural Gas in Minnesota. By *N. H. Winchell.*

Miscellaneous publications.

These embrace some circulars and announcements that were designed in the earlier years of the survey, to bring to the public attention some of the plans and needs of the survey, in which the co-operation and assistance of interested individuals were necessary. Most of them contain nothing of scientific value, and but small editions were printed. They are the following:

1. CIRCULAR No. 1. A copy of the law ordering the survey, and a note asking the co-operation of citizens and others. 1872.
2. PEAT FOR DOMESTIC FUEL. 1874. Edited by *S. F. Peckham.*
3. REPORT ON THE SALT SPRING LANDS DUE THE STATE OF MINNESOTA. A history of all official transactions relating to them, and a statement of their amount and location. 1874. By *N. H. Winchell.*

4. A Catalogue of the Plants of Minnesota; prepared in 1865 by *Dr. I. A. Lapham*, contributed to the Geological and Natural History Survey of Minnesota, and published by the State Horticultural Society in 1875.
5. Circular No. 2. Relating to botany, and giving general directions for collecting information on the flora of the State. 1876.
6. Circular No. 3. The establishment and organization of the Museum. 1877.
7. Circular No. 4. Relating to duplicates in the Museum and exchanges. 1878.
8. The Building Stones, Clays, Limes, Cements, Roofing, Flagging and Paving Stones of Minnesota. A special report by *N. H. Winchell*. 1880.
9. Circular No. 5. To Builders and Quarrymen. Relating to the collection of two-inch cubes of building stones for physical tests of strength, and for chemical examination, and samples of clay and brick for the general museum. 1880.
10. Circular No. 6. To owners of mills and unimproved water-powers. Relating to the Hydrology and water-powers of Minnesota. 1880.

The cost of these publications cannot be stated definitely. They have all been printed by the state contractor for public printing at the rates ruling for "printing of the third class," which is let to the lowest bidder by the standing printing commission consisting of the secretary of state, the state auditor, and the state treasurer. The price varies from year to year. The engraving is estimated and contracted for separately as required. The edition of the annual reports and the bulletins is 2,400 copies and of the final report 5,000 copies. The former are distributed gratuitously, and the latter are sold at $3.50 and $5.00 per volume according to style of binding and quality of paper, though of the latter a generous free distribution is made to libraries and scientists.

Museum and Library.

The General Museum of the university is the outgrowth of the survey. It is stored in the university buildings. Its equipment as well as maintenance is wholly derived from the survey fund. It is a means of instruction to the students in natural science and of enlightenment and pleasure to all visitors. The last report (17th) gave the entries in the geological and mineralogical department 6827, and in the zoological 1633, embracing several times as many specimens. In archæology the entries number 198. Besides these, several valuable collections have been deposited by their owners for temporary exhibition and safe-keeping. The rooms are well-warmed and furnished with secure cases for all specimens.

The library of the survey contains perhaps one thousand books and pamphlets, obtained by exchange and by purchase. It is stored in the office of the state geologist at the university and is used only by the officers of the survey or by students specially interested. It is not a public library and has no regulations for its use.

Cost of the Survey proper.

When the survey began it had an annual appropriation of one thousand dollars. This was increased to two thousand at the first meeting of the Legislature, and five hundred dollars were also appropriated for chemical apparatus for the survey. The cash appropriation of two thousand dollars per year was to continue till the revenue from the Salt Spring lands amounted to that sum and was discontinued in 1879. The Salt Spring lands, aggregating, with the deficit afterward secured from Congress, the sum of 38,643 acres, which could not, in accordance with the terms of existing law, be sold for less than five dollars per acre, were placed in the hands of the regents by the same Legislature to carry on the survey. This gave at once a prospective aggregate net sum of $193,215 with which the survey should be carried on in its various branches.

The reports of the treasurer of the university have been consulted for facts respecting the receipts and expenditures of the regents for the survey, and they show the following results. This record is complete to July 31, 1888, the date of the last fiscal statement of the university:

Sums reported received by the university treasurer for the geological survey.

Oct. 2, 1872.	Cash from the state treasurer	$1,000.00
June 16, 1873.	" " "	2,500.00
Aug. 13, 1874.	" " "	2,000.00
June 5, 1875.	" " "	2,000.00
June (?), 1876.	" " "	2,000.00
July 1877.	" " "	2,000.00
Apr. 5, 1878.	" " "	1,000.00
June 26, 1878.	" " "	1,000.00
Oct. 30, 1878.	Cash sale of Salt Spring land (balance)	2,893.64
Dec. 1879.	" from state treasurer	2,000.00
Feb. 5, 1880.	" sales of Salt Spring land	3,140.44
Apr. 24, 1880.	" " "	957.92
Apr. 24, 1880.	" " "	390.00
July 2, 1880.	" " "	941.23
Aug. 5, 1880.	" " "	67.40

Aug. 7, 1880.	Cash sales of Salt Spring land	17.73
Dec. 10, 1880.	" " "	1,138.17
Dec. 10, 1880.	" " "	170.00
Jan. 26, 1881.	" " "	18.84
June 28, 1881.	" " "	941.23
July 13, 1881.	" " "	146.48
July 25, 1881.	" " "	17.73
Oct. 29, 1881.	" " "	1,009.36
Nov. 10, 1881.	" " "	25.16
Jan. 16, 1882.	" " "	25.00
May 26, 1882.	" " "	598.45
June 20, 1882.	" " "	693.90
June 24, 1882.	" " "	152.32
June 24, 1882.	" " "	152.32
June 24, 1882.	" " "	152.32
June 24, 1882.	" " "	151.13
June 24, 1882.	" " "	285.60
June 24, 1882.	" " "	47.60
July 1, 1882.	" " "	1,083.58
July 6, 1882.	" " "	539.70
July 21, 1882.	" " "	951.21
Aug. 4, 1882.	" " "	775.19
Dec. 5, 1882.	" " "	919.21
Dec. 27, 1882.	" " "	11.90
Jan. 18, 1883.	" " "	975.00
Feb. 9, 1883.	" " "	170.00
Feb. 14, 1883.	" " "	1,238.15
Mar. 10, 1883.	" " "	116.40
Mar. 13, 1883.	" " "	231.43
Apr. 17, 1883.	" " "	215.60
June 9, 1883.	" " "	764.32
June 28, 1883.	" " "	228.48
June 30, 1883.	" " "	322.43
July 7, 1883.	" " "	1,116.13
July 14, 1883.	" " "	246.68
July 16, 1883.	" " "	2,176.00
July 26, 1883.	" " "	600.00
Nov. 22, 1883.	" " "	50.55
Jan. 10, 1884.	" " "	581.94
Feb. 19, 1884.	" " "	539.70
May 15, 1884.	" " "	240.00
June 7, 1884.	" " "	325.20
July 3, 1884.	" " "	550.91
July 12, 1884.	" " "	597.06
Aug. 6, 1884.	" " "	91.98
Oct. 6, 1884.	" " "	527.10
Oct. 18, 1884.	" " "	210.50
Oct. 22, 1884.	" " "	687.67
Nov. 5, 1884.	" " "	187.66

Apr.	22, 1885.	Cash sales of Salt Spring land	116.90
June	16, 1885.	" " "	546.00
June	23, 1885.	" " "	288.70
June	30, 1885.	" " "	212.50
July	6, 1885.	" " "	550.91
July	8, 1885.	" " "	758.71
Sept.	3, 1885.	" " "	467.50
Sept.	23, 1885.	" " "	71.04
Oct.	24, 1885.	" " "	81.85
Oct.	26, 1885.	" " "	787.40
Nov.	16, 1885.	" " "	121.00
Nov.	24, 1885.	" " "	421.44
Mar.	31, 1886.	" " "	1,372.41
Apr.	6, 1886.	" " "	217.50
May	22, 1886.	" " "	780.50
June	24, 1886.	" " "	84.00
July	17, 1886.	" " "	39.90
July	2, 1886.	" " "	71.62
July	10, 1886.	" " "	244.92
July	20, 1886.	" " "	494.50
July	27, 1886.	" " "	56.41
Oct.	20, 1886.	" " "	187.20
Oct.	22, 1886.	" " "	1,537.09
Nov.	4, 1886.	" " "	68.20
Nov.	10, 1886.	" " "	194.80
Apr.	15, 1887.	" " "	25.20
June	7, 1887.	" " "	68.91
June	21, 1887.	" " "	56.40
June	23, 1887.	" " "	152.40
July	8, 1887.	" " "	71.46
July	20, 1887.	" " "	476.00
Aug.	18, 1887.	" " "	75.38
Oct.	13, 1887.	" " "	23.28
Oct.	29, 1887.	" " "	1,976.98
Nov.	21, 1887.	" " "	45.00
Jan.	27, 1888.	" " "	640.00
Jan.	27, 1888.	" " "	172.50
Feb.	27, 1888.	" " "	19.33
Feb.	29, 1888.	" " "	25.35
Mar.	13, 1888.	" " "	1.00
Mar.	22, 1888.	" " "	139.20
June	20, 1888.	" " "	7.00
July	2, 1888.	" " "	71.69
July	3, 1888.	" " "	476.00
July	7, 1888.	" " "	75.38
July	3, 1888.	" " "	71.46
July	14, 1888.	" " "	200.00
July	31, 1888.	" " "	56.40

Total receipts for the survey to July 31, 1888 .... $61,605.07

Of this sum $15,000 were received from the state treasurer as proceeds from the laws of 1872 and 1873, making direct cash appropriation for its support, and the rest, or $46,105.07, has been derived from the sales of the Salt Spring lands.

The expenses of the survey, including the General Museum as reported by the regents through the university treasurer, from 1872 to July 31, 1888, amount to $81,061.89, making, for seventeen years, an annual expense of $4,768.34, and showing the Salt Spring fund indebted to the university $19,456.82.

In the treasurer's account with the survey fund, however, are numerous items charged which were incurred for the department of instruction in the university, which was for some years in the charge of the state geologist, which expenses can only by the broadest construction of the law of the survey, be considered as promoting the work of the survey. These aggregate the sum of $12,510.80, and would reduce the total cost of the survey proper and the General Museum to $68,551.09, and to an annual cost of $4,032.41.

But, *per contra*, the survey has reaped substantial benefits from its association with the university. It has office and storage rooms, and laboratories in the university buildings free of rent, and access to libraries and apparatus that to gather together, or to consult elsewhere, would be at great expense.

The geological and natural history survey is one of the important wards of the university, and is constantly demonstrating the wisdom of the law that made it one of its functions to conduct it. The mutual benefits that spring from this relationship need not be dwelt upon here.

Administration.

The regents manage the sales of the Salt Spring lands. In this they are limited in their judgment only by the state law that requires that no state land shall be sold for less than five dollars per acre.

The administration of the survey proper has been almost wholly in the hands of the state geologist. He lays such plans as he chooses, governed by his own appreciation of the financial, economic, scientific and educational circumstances that may be influenced by them. These plans have almost always been submitted to the regents, or to their executive committee, prior to their execution, for their formal approval. In some instances, certain public or wide-spread want for information, expressed in corre-

spondence, or in the public press, such as the demand for information concerning the grasshopper-plague and the ways and means for alleviating the evil, the call for peat-fuel on the woodless prairies, the ravages of insects injurious to horticulture, the general belief in the existence of coal in the state or of mineral wealth in the northern part of the state, the demand for authoritative statements founded on scientific data, touching the nature and extent of our forests, or the quality of our soils, or the water used for domestic purposes, or the probability of brine for the manufacture of salt, or the existence of the necessary conditions for artesian water or burning-gas, or the quality of our native building stones,—these have all been elements that have influenced the plans formed from year to year. While answering these purposes as nearly as possible, the survey has been rendered useful to numerous individuals by private correspondence, preventing the useless expense of ill-guided exploration in many instances, and directly influential in promoting economic industry by advising expenditures where a reasonable expectation existed of remunerative results. Individual instances need not be mentioned.

This economic side of the survey has been kept in mind constantly, though it has not been made conspicuous. This was politic as well as just. The annual reports embody common patent facts, and description cast in a semi-scientific mould. They are addressed primarily to a home constituency, in order to show them the utility of the work of the survey. As the survey becomes grounded in the good will of our own citizens it is strengthened for doing more advanced work, and at the same time finds a constituency that is ready to welcome more strictly scientific publications. It is highly probable that if such a moderate course had not been pursued, the Legislature, instead of always manifesting a good will and determination to have the work well sustained, would have refused the financial aid that has been asked of it, and the work might have had the short-lived existence that has been the fate of so many other state surveys.

Personnel of the survey.

N. H. Winchell, state geologist	1872 ——
Warren Upham, assistant geologist	1879–1885
C. W. Hall, assistant geologist	1878–1880
C. M. Terry, laboratory assistant	1879–1881
O. E. Garrison	Occasional field assistant
P. L. Hatch, ornithologist	1876 ——
C. L. Herrick, zoological collector and laboratory assistant in charge of Mammals	1876–1885
L. B. Sperry, geological assistant	1877
P. B. Rose, chemist	1873
S. F. Peckham, chemist	1873–1880
Jas. A. Dodge, chemist	1881 ——
M. W. Harrington, assistant geologist	1875
Allen Whitman, entomologist	1876–1878
Benj. Juni, Botanical and field assistant	1878
P. P. Furber, field assistant	1873
C. E. Chatfield, field assistant	1873
W. E. Leonard, botanical and field assistant	1875
Horace V. Winchell, field geologist and laboratory assistant	1881, 1885 ——
Albert H. Chester, report on the iron region	1882
Leo Lesquereux, palæobotanist	1883, 1886
O. W. Oestland, entomologist and laboratory assistant	1885 ——
U. S. Grant, conchology and field geologist	1885–1888
J. C. Arthur, botanist	1885–1888
E. O. Ulrich, bryozoans	1885 ——
F. L. Washburn, assistant in ornithology	1885
A. Woodward, B. W. Thomas, } Foraminifera of the Cretaceous	1886–1889
Frank N. Stacy, field assistant	1886–1887
A. W. Jones, field assistant	1886
Alexander Winchell, assistant geologist	1886–1887
A. D. Meeds, field assistant	1888
M. E. Wadsworth, assistant geologist	1886
L. W. Bailey, Jr., botany	1886
E. W. D. Holway, botany	1886
W. F. Trussell, field assistant	1887
H. W. Fairbanks, field assistant	1887
S. W. Ford, draughtsman	1887
W. D. Willard, field assistant	1888

The selection of these men has been made by the state geologist, but their appointment has always been passed on by the regents or by their executive committee. The only guide in making the selections, aside from availability and fitness for the work, has been the clause in the general law requiring the employment of students and graduates of the University of Minnesota when such can be found qualified for the work, and a general enactment of the regents to the effect that the professor of chemistry at the university is, by virtue of his position, to be the chemist of the survey.

These men have not been continuously employed, even for the time expressed above, except in the case of the state geologist, Warren Upham, C. M. Terry, and O. W. Oestlund, but they have been engaged during the season of field-work or to perform some specific work for which they had such compensation as the service demanded.

The salary of the state geologist is $2,400.

The salary of Warren Upham was $1,200.

The salary of C. M. Terry was $1,200.

The salary of O. W. Oestlund is $900.

The salary of C. L. Herrick was from $600 to $1,200.

The chemist is paid a per centum of schedule prices for work he does for the survey. Dr. P. L. Hatch, the ornithologist, is working for the survey from pure love of birds, and asked only the payment of his field and traveling expenses. Other employēs have been paid by the month from fifty to two hundred dollars, or by the job.

Co-operation of the U. S. Coast and Geodetic Survey.

Congress some years ago authorized the United States Coast and Geodetic survey to co operate with the state geological surveys in the triangulation and correct mapping of those states in which the State Legislatures may have provided for such geological and topographical surveys. Several of the States having thus been aided by the Coast and Geodetic survey, the attention of Gov. L. F. Hubbard was called to the matter by the writer in a letter dated March 19, 1884, asking him to make, or authorize to be made, a formal application to the superintendent of the Coast survey for similar aid to the Minnesota survey. Such a request was forwarded to the superintendent, and, on the appropriation by Congress of a small sum specifically for the purpose, a system of triangulation was begun at the university

under the direction of major C. O. Boutelle. This has been continued by Prof. W. R. Hoag, and has resulted in the accurate establishment of many prominent objects in the topography, referred to a base line situated between Minneapolis and St. Paul. In general the present design is to make connection at La Crosse, with the earlier triangulation carried on by the Coast survey across the state of Wisconsin. By means of this triangulation Prof. Hoag made an accurate measurement of the gorge of the Mississippi river between Fort Snelling and the brink of the Falls of St. Anthony, and prepared a map of the gorge itself. By employing the determination of latitude and longitude of the smaller cupola of the university by the Lake survey, under Gen. C. B. Comstock* in 1873, the latitude and longitude of any point covered by the triangulation can be computed.

The result of this triangulation will be felt in the future more appreciatively than at the present time. It necessarily goes slowly, in consequence of the exactness demanded by the nature of the work. It will be for the State to supplement this triangulation with topographic work suitable for the construction of outline and contour or other topographic maps. This is what the geological survey will have to do by and by. Strictly, a topographic map should precede the geological. But in the case of Minnesota much of the state had been mapped geologically before the commencement of careful topographic mapping. This is less to be regretted in a state like Minnesota, where a large portion of the area is nearly flat, and where already the United States township survey had preceded and had furnished a series of maps that are tolerably correct. It could not be avoided, however, since the geological survey could not wait for the uncertain action of Congress, on a question which had not then been brought to its attention. Whatever errors there may be found in the future in the published geological maps of the survey can be corrected readily by reference to the topographic map of the state by counties, that is to be, based on the triangulation by the United States Coast and Geodetic survey. Two of the eastern States (Massachusetts and New Jersey) are actively engaged in this final topographic mapping, that of New Jersey being nearly complete.

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* See the fourth annual report, p. 5.

Benefits resulting from the survey.

Of these it were more appropriate that some one else should write. If no mention be made here of the invisible benefits that result to the state, and particularly to the university by the prosecution of this survey, it will perhaps be proper to enumerate some of the tangible beneficial results that have accrued to the people of the state directly through the agency of the survey.

1. Beginning with the commencement of the survey the first that should be mentioned is the fact that the professorship of geology and mineralogy in the university, with the added work of instruction in botany and zoology, was maintained six years solely at the expense of the survey fund. This also includes much of the equipment, cases, maps and apparatus of that department. The same fund has also placed several hundred dollars worth of books in the general library of the university.

2. The *Salt Spring lands* of the state were saved from being gradually devoured by such enterprises as that of the Belle Plaine Salt company, and were appropriated, through the direct interposition of the survey at a critical juncture, to the prosecution of this far-reaching public enterprise.

3. On the discovery, after a laborious investigation of the official records, of the fact that the State was still entitled to a large additional amount of land under the original grant, the initial efforts of the state geologist were successful in obtaining from the United States, about fifteen thousand acres of indemnity lands which have since been devoted by the Legislature to the support of the survey.

4. The General Museum of the University is one of the tangible beneficial results of the survey.

5. There was a wide-spread belief among the citizens in the southern part of the state, prevalent when the survey began, that workable coal of the age of that found in Iowa could be discovered by making the proper exploration, and individuals had incurred considerable expense in looking for it. One of the first efforts of the survey was to settle this question; and the published result of such investigation went far toward stopping further useless expenditure of money.

6. The agitation of this subject by unscrupulous prospectors and well-drillers culminated in a proposed law, which was introduced in the Legislature of 1883 (?) offering a reward of twenty thousand dollars for the discovery, in the state, of "coal" in work-

able quantities. This law was so drawn that it did not discriminate as to the age or the quality of the coal to be discovered, and any one familiar with the Cretaceous lignites of the state, could have made a legitimate demand for the reward within sixty days after the adjournment of the Legislature. Through the agency and advice of the state geologist this law was adversely reported by the committee having it in charge. It is only on the principle of "a penny saved is two pence gained" that this can be claimed as one of the tangible effects of the survey.

7. A similar law ordering the appointment of a "commissioner of peat," at a salary of two thousand dollars per year, was also defeated in the State Legislature, largely through the influence of the survey in 1874.

8. A law ordering the donation of further subsidy to the Belle Plaine salt company, and another for the investigation of the grasshopper-plague, and another appointing a state mineralogist with special reference to supposed great wealth of the state in gold and silver, each looking to the unguided expenditure of the revenues of the state, were severally proposed in the State Legislature, and were either rejected or shown to be unnecessary by the existence and the agency of the survey.

9. In the prosecution of the regular work of the survey general attention has been called to the economic resources of the state. The survey has been directly instrumental either in investigating in the first instance, or in guiding by counsel when once begun, nearly all the industries of the state that arise from the rocky substructure. This has been done officially and by private correspondence. The native building-stones, especially, have been compared with those from other states, and some of their excellencies have been brought out prominently, resulting in a great increase of the use of stone native to Minnesota.

10. In 1877 an examination was made of the water used for domestic purposes in the western part of the state. It had been discovered that very many of the common wells were foul, and that serious diseases that frequently terminated fatally were traceable to the use of the water in this condition. So general and wide-spread was this difficulty that serious alarm was felt by parties who were largely interested in the settlement and habitability of the prairies, particularly in the valley of the Red river of the North, lest the growing evil should render the country unfit for general agricultural occupancy. But the examination showed that the evil was due, not to any unhealthfulness

inherent in the water but to the general habit of using white pine planks for curbing in the wells. In the open air, the water of the prairies, which is naturally somewhat alkaline, confined in the impervious clay-reservoirs, such as nearly every well was, will act rapidly on any organic matter that comes in contact with it. The pitch of the pine was thus converted into organic acids, giving off sulphuretted hydrogen. Infusorial organic germs took up their abode in the foul waters, and the natural result of the use of such water inevitably followed. It was at once recommended that the use of wooden curbing be abandoned and that in its place some earthen, stone, brick or iron substance be used. This recommendation was widely published, both in Minnesota, and in the newspapers of Manitoba.

The consequence was a rapid decline of the evil. Many wells which had been abandoned were re-curbed with other materials. It was very soon known that pine well-curbing generated disease, and in a year or so nothing more, or very little, was heard further concerning the supposed foul waters of the western prairie portion of the state. The correction of this evil, and the removal of the suppressed alarm that was felt by some capitalists and by the health officers of the state, may be considered one of the most important visible benefits that have resulted from the survey.

11. At the same time the survey called attention to the possibility of obtaining artesian water at a moderate depth in the drift deposits over a wide tract of country in the northwestern part of the state, a circumstance that has latterly been widely improved with the most satisfactory results.

While these material benefits can easily be enumerated, those that are invisible cannot so readily be pointed out. Some good must result from a diffusion of knowledge concerning the physiographical features of the state, and from the publication of accurate statements concerning its natural, undeveloped resources. There must be some benefit to the state in having its geology and natural history known. The scientific facts that are ascertained help to swell the data on which important conclusions are based, and to point out needed corrections in others that may have been published.

Scientific results of the Survey.

The additions to science that have sprung from the survey cannot be exactly enumerated. They are the common property of educators and scientists who may wish to make use of them.

Many facts have been published, the value of which cannot now be estimated, but they will go with other facts, some now known, and others to be learned, in Minnesota or elsewhere, to construct, by and by, general principles of interpretation of nature by which man becomes better and better acquainted with the laws and the circumstances that environ him, and with the great history of which he forms a part. Not in all cases have the conclusions, to which the published facts point, been stated, nor indeed have they been known. The principles deducible from a body of facts have to be the last fruits of an investigation, and in the case of a geological survey, while the indicated results may be foreshadowed by an examination of such incomplete data as the survey may afford from time to time, the final conclusions can be given only after the search for facts has been finished. Some such partial results have been published in the annual reports, and some important general truths have been announced in the final volumes (Vols. I. and II.) that have been issued.

In order, however, to indicate more definitely some of the scientific results of the work of the survey as they appear at present, the following enumeration is given, with references to the pages of the various reports in which the publication was made.

IN GEOLOGY.

1. Origin of kames, or "hogsbacks," supposed to be due to streams running on the ice and in gorges in the ice at the time of the glacial epoch, First Report, p. 62. This was first suggested in a report on Delaware county, Ohio [Geology of Ohio, Vol. II., p. 305] and a little later by N. O. Holtz, of the Geol. Sur. of Sweden [Geol. Fören. i Stockholm Forh. Band III., No. 3] and Warren Upham. [Geol. N. H., Vol. III., pp. 13 and 14.]

2. Origin of river-gravels and of "glacial lakes" on the open upland, and drift-covered prairies, First Report, p. 62.

3. Former existence of a lake of fresh water over the Red River valley, in northwestern part of the state. First Report, p. 63; Sixth, p. 31; named *lake Agassiz*, Eighth Report, p. 84; its approximate extent, Tenth Report, pp. 5, 141. [This lake was first suggested by D. D. Owen.*]

* Geology of Wisconsin, Iowa and Minnesota, p. 175, *et seq.* The suggestion of Owen was enlarged on by Henry Yule Hind, who added some definite data. Reports of progress; together with a preliminary and general report on the Assiniboine and Saskatchawan Exploring Expedition, made under instructions from the provincial secretary, Canada, by Henry Yule Hind. Presented to both Houses of Parliament by Her Majesty's command, August, 1860. London, 1860, pp. 178–181. Also, Narrative of the Canadian Red River Expedition of 1857, and of the Assiniboine and Saskatchawan Expedition of 1858. Two Vols., 1860, Vol., II., p. 230 *et seq.*

4. Suggestion of two glacial epochs in Minnesota. First Report, p. 61; Third, p. 185; Fourth, p. 62; Fifth, p. 36. [See also *Geology of Ohio*, Vol II., pp. 266–67, 303, 330.]

5. Separation of the Potsdam sandstone from the St. Croix sandstone. First Report, p. 68; Fifth, p. 29; Tenth, p. 123.

6. Probable non-existence of the Carboniferous rocks in Minnesota. Second Report, p. 76.

7. Separation of the "Lower Magnesian" into its two parts and the establishment of the sandstone member between them. The Jordan sandstone named, Second Report, p. 138; The St. Lawrence limestone named, Second Report, p. 152; defined, Fourth, p 32; Eighth, p. 103. The Shakopee limestone named, Second Report, p. 138; defined, Fourteenth, p. 325.

8. The decayed condition of the granites underneath the Cretaceous, in the Minnesota valley. Second Report, p. 163.

9. Establishment of latitude and longitude at various points in Minnesota through the aid of the U. S. Lake Survey. Fourth Report, p. 384.

10. The Cretaceous unconformable over the Cambrian at Mankato. Second Report, p. 178.

11. First fossils in the St. Peter sandstone. Fourth Report, p. 41.

12. Cause of the driftless area. Fifth Report, p. 36.

13. Approximate establishment of the date of the second, or last, glacial epoch, by the recession of the falls of St. Anthony. Fifth Report, p. 156; Final Report, Vol. II., p. 313.

14. The slates at Northern Pacific Junction the same formation as those at Little Falls. Sixth Report, p. 49.

15. Probable palæolithic man at Little Falls. Sixth Report, p. 53.

16. Definition of "Mesabi iron range" in Minnesota. Seventh Report, p. 21; Eleventh, p. 155; Thirteenth, pp. 24, 37.

17. Ten new species of fossils. Eighth Report, p. 60.

18. Three new species of fossils. Ninth Report, p. 115.

19. Position and extent of glacial moraines in Minnesota. Eighth Report, p. 72; Ninth, p. 182.

20. Castoroides Ohioensis at Minneapolis. Eighth Report, p. 181.

21. Unconformity between the Grand Portage slates [Animike] and the talcose or sericitic schists [Keewatin] at Gunflint lake. Ninth Report, p. 82; Tenth Report, p. 88; Tenth, p. 132; Eleventh, p. 168; Sixteenth, pp. 69, 73, 67, 108, 239, 258, 268, 323, 357.

22. Extent of the moraines of the second glacial epoch in Minnesota and Iowa. Ninth Report, p. 298.

23. Titanic ore a constituent part of the gabbro. Tenth Report, p. 80; Fifteenth Report, p. 212.

24. The Labradorian Laurentian [the gabbro] extends, with some contemporary syenite, from Duluth to Little Saganaga lake and further eastward. Tenth Report, p. 98–101, 113.

25. The Quartz porphyry of the Great Palisades a part of the Cupriferous, and the equivalent of the "Red Rock," or red syenite associated with the gabbro. Ninth Report, pp. 36, 39, 58; Tenth, pp. 66, 75, 77, 99, 101, 110, 112; Thirteenth, p. 36.

26. Discovery of the Ogishke conglomerate. Tenth Report, p. 89.

27. The Animike the equivalent of the Taconic. Tenth Report, p. 132; Eleventh, p. 168; Thirteenth, p. 131.

28. Definition of the beaches of lake Agassiz. Eleventh Report, p. 141.

29. The Vermilion and Mesabi iron ranges visited and described. Ninth Report, pp. 103, 108; Eleventh, pp. 155, 168; Thirteenth Report, p. 20.

30. One new species of fossil. Twelfth Report, p. 8.

31. The iron ore of the Mesabi range in a different formation from that of the Vermilion range. Thirteenth Report, pp. 22 (fig. 5), 24, 37; Sixteenth, p. 79.

32. Three iron ore formations in Minnesota. Thirteenth Report, p. 24; Fifteenth, p. 212.

33. Paradoxides and Lingula (new species) in the red quartzyte (so-called Huronian) at Pipestone. Thirteenth Report, p. 65.

34. The "upper Laurentian," or Norian, the equivalent of the gabbro, or "Mesabi range," of Minnesota. Thirteenth Report, pp. 127, 140.

35. The Taconic the equivalent of the Huronian. Thirteenth Report, p. 135; Sixteenth, p. 170.

36. Foraminifera of the Cretaceous in the boulder clays of Minnesota. Thirteenth Report, p. 164.

37. Elephas primigenius in Winona county. Thirteenth Report, p. 147.

38. Thirty-nine new fossil species. Fourteenth Report, p. 57.

39. One new family of fossils. Fourteenth Report, p. 104.

40. One new genus of fossils. Fourteenth Report, p. 83.

41. Three new genera of fossils. Fourteenth Report, p. 107.

42. Four new species of fossils. Fourteenth Report, p. 313.

43. The Vermilion group, or crystalline schists named. Fifteenth Report, p. 4; conformable with the Laurentian gneiss, Fifteenth Report, pp. 127, 178, 296; Sixteenth, p. 335; Seventeenth, p. 32.

The jaspilyte embraced in basic eruptive rock now converted to chlorite schists. Fifteenth Report, pp. 221, 269, 319, 326; Seventeenth Report, pp. 37–42, 123.

44. Mica schist derived from hornblende schist. Fifteenth Report, pp. 338, 357; Seventeenth, p. 32.

45. Derivation of gneiss *in situ* from fragmental rock. Fifteenth Report, pp. 353, 361, 368; Sixteenth, pp. 69, 81, 104, 107.

46. Three new species of fossils. Fifteenth Report, p. 478.

47. Stratigraphic position of the Animike. Fifteenth Report, p. 356; Sixteenth, pp. 79, 81, 87, 108.

48. A driftless area in N. E. Minnesota. Fifteenth Report, p. 350.

49. Potsdam (or primordial) quartzyte of S. W. Minnesota the equivalent of the upper quartzyte of the Huronian in Canada. Sixteenth Report, p. 22.

50. Gabbro and felsyte in the area of the original Huronian. Sixteeenth Report, pp. 29, 27.

51. The Animike the equivalent of the Huronian. Sixteenth Report, pp. 38, 352.

52. The upper Huronian (or Potsdam) quartzyte unconformable over the iron ore formation at Negaunee, Mich. Sixteenth Report, p. 44; and at Ishpeming, Sixteenth Report, p. 46; and at Bessemer, Sixteenth Report, p. 55.

53. The Gogebic iron ore on the horizon of the Animike of Minnesota. Sixteenth Report, p. 59.

54. The "Laurentian" overlies the Gogebic strata at Ironwood, Mich. Sixteenth Report, p. 58.

55. The Keewatin schists conformable with the Vermilion mica schists. Sixteenth Report, pp. 76, 350; Seventeenth, p. 37.

56. The Vermilion sediments largely of eruptive origin, but principally distributed by sedimentation. Sixteenth Report, p. 77.

57. The Animike becomes nearly vertical, and embraces a part of the great Ogishke conglomerate. Sixteenth Report, pp. 91, 98.

58. "Laurentian" gneiss overlying Keewatin strata. Sixteenth Report, p. 104.

59. The Vermilion ore not Huronian. Sixteenth Report, p. 175.

60. Two unconformable slate formations in the Marquette region. Sixteenth Report, pp. 178, 359; Seventeenth, p. 43.

61. Conglomerate in Laurentian gneiss. Sixteenth Report, pp. 219, 293, 298, 334.

62. The jaspilyte not of eruptive origin but arranged by sedimentary deposition. Fifteenth Report, pp. 223-247.

63. Suggestion that the crystalline schists (Vermilion series) may be due to hydro-thermal action at deep levels, on the volcanic tuffs, stratified by sedimentary action, of the age of the Keewatin, and may occur at different levels in the Keewatin strata. Seventeenth Report, p. 36.

64. Demonstration by the deep well at Stillwater, that the Kewenawan rocks are not of Mesozoic age. Bulletin No. 5, p. 26.

65. The gabbro outflow, of the age of the Pewabic [Potsdam?] quartzyte. Sixteenth Report, p. 88; Bulletin No. 5, p. 34. (Section of the Duluth deep well.)

66. Microscopic description of the peridotytes, gabbros, diabases and andesytes of the state. Bulletin No. 2.

IN ZOOLOGY.

1. Twenty-seven species of mammals named from the vicinity of Big Stone lake, one variety new. Thirteenth Report.

2. Two hundred eighty-one species of birds credited to the state. Ninth Report.

3. One hundred species of aphids credited to the state, forty-two of which are new to science. Fourteenth Report and Bulletin No. 4.

4. Eighty-one species of Crustaceans credited to the state, of which twenty-seven are new to science. Fifth, Seventh, Tenth, and Twelfth Reports.

5. Eighty-seven species of mollusks are credited to the state. Fourteenth and Sixteenth Reports.

6. Eighty-nine species of mollusks are reported from Winona county. Sixteenth Report.

IN BOTANY.

1. Fungi in Minnesota, 558 species identified. Fifth Report. [Published simultaneously in the Bulletins of the Minnesota Academy of Sciences.]

2. Other plants identified in Minnesota, 2107. Twelfth Report and Bulletin No. 3.

3. Thirteen species and four varieties of plants new to science. Twelfth Report and Bulletin No. 4.

4. Definition of the forested area of the state, and of the latitude limits of some of the trees. Twelfth Report.

THE FUTURE WORK OF THE SURVEY.

Besides the foregoing results, there are important scientific memoirs and reports that await publication. These form two further final volumes, and were offered for publication at the last meeting of the State Legislature. One contains the final reports on Birds and on Mammals, and the other is mainly palæontological. The palæontological volume will be No. 3 of the final volumes.

The unfinished work of the geological survey proper lies in the northern portion of the state, embracing the crystalline rocks and the various questions of economic and technical geology that pertain to them. This is the most important, as it is the most difficult and costly, of all the work yet done by the survey. A large amount of this kind of work has been done. It remains to thoroughly examine the specimens collected, give their relations, construct the geological maps and to publish the results.

And when this survey is finished, it can be considered only a commencement of the research that will yet be conducted on the geology of the state. It is an effort to put into systematic relationships some of the obvious facts that can easiest and quickest be gathered up by a geological observer. So far as it goes it is useful, and is absolutely necessary to the future geologist who would inquire further into these relationships. It will furnish for him a broad stepping-stone from which he may examine more minutely many things that now have to be passed over unstudied, just as the survey of D. D. Owen has furnished for us an earlier classification from which to take departure in all our examinations.

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GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

N. H. WINCHELL, STATE GEOLOGIST.

BULLETIN No. 2.

PRELIMINARY DESCRIPTION

OF THE

PERIDOTYTES, GABBROS, DIABASES AND ANDESYTES OF MINNESOTA.

BY M. E. WADSWORTH.

ST. PAUL:
THE PIONEER PRESS COMPANY.
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NOTE.—The work embodied in the following report by Dr. Wadsworth was done in 1886, in the laboratory of the survey at the University of Minnesota. It should strictly be considered a part of the annual report of progress for that year. But in accordance with the terms of a recent law of the legislature, and because that volume would be unduly swollen if this were included in it, this contribution to the progress of the survey is herewith issued as one of the Bulletins of the survey.

Consistent with the practice of the survey, though not in accordance with that of Dr. Wadsworth, the spelling of rock names is made in *yte*, in order to distinguish them from mineral names in *ite*. This distinction was proposed by Prof. J. D. Dana, and serves well the purpose for which it was instituted.

N. H. WINCHELL.

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REPORT.

Preliminary Description

of the

Peridotytes, Gabbros, Diabases, and Andesytes of Minnesota.

by

M. E. Wadsworth.

[Bulletin No. 2 of the Geological and Natural History Survey of Minnesota.]

INTRODUCTORY.

It is proposed in the following pages to give a preliminary description of certain types of Minnesota rocks, to serve as a framework for a more complete discussion of the same in the final report. In order that the manuscript should be in the hands of the printer in season for the annual report for 1885, much work that it was desirable to do has been left undone, and many matters, upon which the investigations were in too incomplete a state even for the preliminary publication, have been omitted, or only briefly touched upon. This has been the case with the large and important group of melaphyr rocks, upon which the work is too incomplete for publication.

The field relations and to some extent the microscopic characters of the rocks described in the following pages have been given by the state geologist in the annual reports for 1879, 1880, and 1881, and in volume I of the final report. In some cases it will be found that the field relations have led the state geologist to different conclusions concerning the nature of the rocks in question from those adopted by the writer, who has based his views upon the correlation of the microscopic characters of rocks and their field relations, as studied by him elsewhere. So, too, some difference of opinion has been found in relation to the mineralogical constitution of a portion of the specimens. Since we have approached these questions from different standpoints, it is not in the least surprising that somewhat different views should be held by us; and it is a matter for congratulation that such is the case, as only through diversity of opinion does advance take place in any science or in any subject in this world of ours.

It is to be hoped that through further field examination and the microscopic study of other specimens, these questions, when important, can be settled in one way or another for the final report. The writer does not assume, for a single instant, that his views are of necessity correct or the only ones to be held; but simply that he holds them as the ones which appear to him to be correct with the light which he now has. As the writer has already pointed out * in questions concerning the nature of rocks, the field evidence must take precedence over the microscopic, and that the former when clear must decide all questions in dispute.

At the present time there are two schools of petrographers engaged in active work upon rocks.

One school makes the mineral constituents of the rocks the principal objects of attention, giving the time mainly to questions relating to the crystallographic, optical, and chemical characters of these minerals, and to their mechanical separation and isolation. The nomenclature of the rocks is in general based on the minerals found in them, and but little attention is given to the field relations or alteration.

The second school, to paraphrase a remark of Sir William E. Logan about fossils, "uses the minerals but does not describe them." It bases its work largely upon the field relations of the rocks and traces the changes in different portions of the rock mass, attributing the resulting altered rock, let it be now schist, dioryte, or what not, to the rock from whose alteration it was produced, let that be basalt, diabase, andesyte or any other form, as the case may be. The minerals are always looked upon as subordinate to the rock and not superior to it, for the mineralogical composition is considered as changeable and changing.

In the first school are included nearly all of the German, French, and American petrographers, while in the second school are the English petrographers, Lossen, Lehmann, Reyer, Rothpletz and some others amongst the Germans, and myself amongst the Americans.

The first school is an all powerful aid to the mineralogist and has advanced to an extraordinary degree our knowledge of minerals, particularly as they occur in rocks; and although the writer has criticised strongly in the past the mineralogical method, it has been only against those methods as applied to

* Geology of the Iron and Copper Districts of Lake Superior, 1880, pp. 43, 73, 74.

rocks as such, and never against the value of the work mineralogically. These criticisms were made for the reason that the writer believed then, and does so now, that the method of the first school, when rigidly applied to rocks, placed unlike ones together and separated those which were alike, i. e., geologically but not mineralogically. That is, hand specimens would be classed by this school as entirely different species, when in reality they were the same rock mass, the variation in structure and composition being solely due to alteration. When the mineralogical method was applied to rocks in this manner it became a hindrance instead of a help to the geologist and led to confusion. While I would still criticise the application of this method to rocks as such, my criticisms have never been intended to apply personally, as many of my warmest friends, to whom I am deeply indebted, are workers in that school, and most thorough and conscientious work have they done. No one can work in petrography without rendering due credit to the wonderful observational and descriptive powers of Zirkel; to the patient, painstaking labors and remarkable knowledge of Rosenbusch; and to exceedingly valuable researches of Fouque, Levy, Cohen, Renard, Streng, Tschermak, Tornebohm, Thoulet, Wichmann, and numerous others who constitute the *mineralogical* or rather the *micro-mineralogical school* of petrographers.

The second school may be properly styled the *geological or historical school* of petrographers; and the difference between the two schools is far less marked at the present time than formerly, many observers belonging in part to both, and others holding intermediate grades of belief. While the mineralogical school is still in the ascendancy, the current is now setting strongly in favor of the geological school, and many of the strongest papers in behalf of that school are now being published by the members of the micro-mineralogical one; although the authors, themselves, fail to see the far-reaching application of their work. It is indeed probable that in comparatively few years both schools will be united by the advance of the micro-mineralogical school to the ground occupied by the geological petrographers, as the former school is now moving rapidly in that direction. In fact the actual relation of the two schools to each other is much the same as that which the palæontologist holds to the stratigraphical geologist.

However great and valuable may be the knowledge of fossils which the palæontologist has, that knowledge alone will never yield to him the structure and history of the earth's fossiliferous strata—the solution of those problems is for the stratigraphical geologist, even if he have but a thousandth part of the knowledge of fossils as such, that the palæontologist possesses. So in petrography the most critical and accurate knowledge of minerals as such, whether in rocks or out, will never enable one to read the story of the origin, relations, vicissitudes and natural classification of rocks. That is the part of the geological petrographer—even if his knowledge of minerals as such, is of the crudest kind in the eyes of the micro-mineralogist.

Although I had worked in an amateurish way for a number of years in regions of granites, crystalline schists, sandstones, and limestones, my petrographical work proper did not commence until the early portion of 1874. My work was of course affected by the writings of Zirkel, Rosenbusch and Tschermak, but I was perhaps at that time most deeply influenced by the theoretical views of Allport, whose work it has always seemed to me has never received the credit or attention that its merit deserves. My work then consisted in studying the field relations of a large and complicated series of dikes of different ages, and then unknown composition, in the vicinity of Boston; and the microscopic study of the same.

The results of my studies showed that these rocks were originally augitic and belonged to the basic rocks. These were classed as altered forms of doleryte and basalt, under the names of diabase and melaphyr. The normal constituents of these rocks were said to be augite, feldspar, and magnetite, while the viridite, most of the biotite, part of the hornblende, the prehnite, chalcodite, and hematite were the products of alteration of the original minerals.

It was further stated that from this same series of rocks there could be collected as typical ones, specimens which both macroscopically and microscopically could be and had been pronounced to be basalt, diabase, melaphyr, syenite, aphanyte, dioryte, impure limestone, chlorite schist, etc., etc. Yet the study of these rocks showed that they were only altered forms of one and the same basaltic rock, the different types passing into one another, while the coarseness of crystallization was dependent on the size

of the dike or boss. So, too, the amount of alteration was found to be dependent upon the relative ages of the rocks, although the division of rocks into older and younger was rejected.*

In 1878 the writer also showed that the hornblendic † and micaceous granites of Eastern Massachusetts were the same rocks, and passed into each other in the same continuous mass. Also that porphyritic and non-porphyritic characters belonged together in the same dike, and that through alteration the interior of a dike might differ greatly in mineralogical character, forming utterly different rocks, if they were named according to the prevailing nomenclature. The associated basic rocks were all looked upon as altered basalts, and according to their coarseness of texture classed as diabases or melaphyrs. ‡

In 1879, after having studied several thousand thin sections of modern and ancient eruptive and sedimentary rocks, including metamorphic forms, with added field work, the present writer concluded, in substance, that a mineralogical classification of rocks was an impossibility, and that no natural division separated the tertiary rocks from the pre-tertiary ones, and that the divisions older and younger could not be held. He placed under a specific name certain types of rock and classed under each species every form of that rock, whether it was glassy, coarsely or finely crystalline, schistose, metamorphic, fragmental, or otherwise. The rocks of any species were to be followed through every alteration, whether chemical or mechanical, and kept under that specific name, designating the modifications by varietal names, if desirable on account of their importance.

It was further pointed out that the eruptive rocks through alteration were so metamorphosed as to closely simulate the characters of sedimentary (metamorphic) rocks, and to pass under the same names.

Under the term basalt were placed, as alteration forms of it, melaphyr, diabase, gabbro, and the majority of the diorytes as well as the majority of the euphotides, and all other rocks derived from basalt. It was further pointed out that augite and hornblende andesytes were one and the same species, the augite

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* Proc. Bost. Soc. Nat. Hist., 1877, XIX 217-237.

† It may be mentioned here that Rosenbusch called my attention later to the fact that the blue hornblende which I had described in these granites was the rare variety known as glaucophane. (See also Descriptive Catalogue of American and Foreign Rocks, 1883, p. 16).

‡ Proc. Bost. Soc. Nat. Hist., 1878, XIX. 309-316.

arising from the recrystallization of the dissolved hornblende material in the andesytes; and that the so-called species of propylyte, porphyryte, hornblende-porphyry, black-porphyry, part of the felsyte or felsyte-porphyry, and part of the diorytes, etc., were simply altered states of andesyte. Further, that the felsytes (including quartz-porphyry) were simply altered rhyolytes. Also that many other old or metamorphic rocks, designated by various names, were simply altered states of rocks which were once identical with modern eruptive rocks.

It was further stated that quartz and hornblende existed as foreign, indigenous, and alteration products in rocks, and that all the sulphides, carbonates, hydrous minerals, epidote, and part of the feldspar, etc., were the products of alteration or infiltration after the consolidation of the eruptive rock.

The meaning and intention of that paper was to convey the idea that the eruptive rocks proper could be arranged under a few species, like basalt, andesyte, trachyte, and rhyolyte,* and that the pre-tertiary, or older eruptive rocks, now known by different names, like gabbro, melaphyr, granite, felsyte, syenite, porphyry, porphyrytes, etc., are rocks which originally were once identical with the modern forms, although, owing to greater depth at the time of solidification, they may have been more coarsely crystalline than their modern representatives. But, otherwise than this coarseness of texture, when congenital, their present differences from their younger types are due solely to alteration or to infiltration; which alterations are molecular or chemical, and were brought about through the medium of percolating waters, hot or otherwise, even if induced by pressure or any other geological agent.

Further, that all sedimentary rocks were derived directly or indirectly from the eruptive ones, and although many of the metamorphic rocks (schist, gneisses, etc.,) are altered sedimentary rocks, yet many of these metamorphic or foliated rocks are also the result of direct alteration of non-fragmental eruptives *in situ*. These views, as published then † and enforced or republished from time to time since, constitute, so far as the writer is aware, the most sweeping and widespread generalizations, extended to all rocks, that have been published by any

* To which the author has since added siderolyte, pallasyte, peridotyte, and jaspilyte.

† On the Classification of Rocks; Bull. Mus. Comp. Zool, 1879, V. 275-287.

member of the geological school of petographers. And although at the time of the publication of those views the writer stood alone amongst American petographical workers, there has been since 1882 a series of papers published by Becker, Hague, Iddings, Irving, Van Hise, and Williams, which, are mainly of a local character, and for the most part cover a somewhat limited range of rocks. Yet within that range these papers sustain in a remarkable degree not only the present writer's above given generalizations but also many other of his prior-published conclusions—which confirmation, judging from the papers, the writers themselves are unaware of, possibly not seeing the natural conclusions following from their own work, as they endeavor to keep well within the limits of the micro-mineralogical school.

The European geological petrographers hold priority in the publication of their views, yet none appear to have taken so extended a generalization as myself, as they have been working on less diversified rock material; however, after personal discussion of our various views and methods of work with Bonney, Judd, Teall, Rutley, and Cole in England, and Lossen, Lehmann, Reyer and Rothpletz in Germany and Austria, it became evident that we were all working on the same lines and to the same end, even if our certain terminology differed in certain respects. For instance the same general changes that Lehmann was able to show me, had been observed by me in almost every instance, in American rocks, and made part of the basis of my published conclusions. But those changes were referred by myself to the action of percolating waters acting, of course, under the influence of earth movements or any other force that might affect them, while they are attributed by Lehmann almost entirely to pressure.

The same general parallelism of occurrences was also found to exist between the European altered rocks shown by Lossen, Bonney, Judd, Teall, Rutley, and others and American altered forms observed and studied by the writer.

It certainly seems to the writer that the tracing out of the relations of rocks to one another and following them into their metamorphic conditions is the work of the petographer that is of the greatest value to the geologist and one that is very rapidly coming to the front.

One peculiarity of the writer's work has been to place the

altered rock under the species of which it was an altered representative, for instance, a dioryte if it could be shown to be from a basaltic rock, had its name written as follows:

Basalt, dioryte.

If it was found to be from an andesyte then the name was:

Andesyte, dioryte.

This indicated that the rock was now in the condition in which it would be called by lithologists generally a dioryte, but that it was a dioryte formed from the alteration of a rock which once possessed the characters of a basalt or of an andesyte, as the case might be. So, too, if a hornblende schist was formed from the further alteration of a diabsse, itself an altered form of basalt, the name was written *basalt, diabase, hornblende schist*, the last name indicating its present condition, the others indicating its former states. This mode of labeling has even been carried out in the case of quartz, which has been found to replace a melaphyr, leaving the forms of the feldspar intact. This was designated as follows:

Basalt, melaphyr, quartz.

Such a method has been criticised with the statement that all it was desired to know was that the rock at the present time was quartz. Surely if it is of any value to call quartz which has replaced a coral or a gasteropod shell by the name of the replaced fossil it is of value to know not only that the above rock is now quartz but also that it has replaced a former rock belonging to the melaphyre variety of basalt; and it is an advantage to tell the story in three words, as is done above. Of course the term quartz would alone be used in speaking of such a specimen except when placed in a systematic arrangement. So, too, the term hornblende schist, dioryte, diabase, felsyte or porphyryte, would alone be used in speaking or writing of such rocks unless one was labeling them or arranging them in a systematic manner.

I have never used, or proposed to use, as my critics have stated, the nomenclature, *basalt-gabbro-dioryte*, or *basalt-melaphyr*, although I have stated such a system could be made, if desired, out of the one proposed by me.* But even if I had, it would not be any more cumbersome than the *gabbro-dioryte, hypersthene-augite-andesyte* or *biotite-muscovite-hornblende-granite* of the same objectors.

* Lithological Studies, 1884, pp. 57-59.

In 1879–80 the writer spent much time in the study of the copper and iron districts on the south shore of lake Superior, thus gaining a personal knowledge of a region and rocks similar to those which have been placed in his hands by the Minnesota geological survey.

In that work the basic eruptive rocks were found to be much altered in places, the augite being largely replaced by hornblende either entirely, or else cores of the augite were left in the centre. This was the case both with green and brown hornblende, while orthoclase, quartz, biotite, chlorite, titanite, actinolite, viridite, epidote, etc., were found as alteration products in these old basalts; which in many cases had altered to such an extreme degree, that they were both macroscopically and microscopically rocks which all lithologists would pronounce to be in their present condition dioryte, quartz dioryte, diabase, melaphyr, chlorite schist, hornblende schist, actinolite schist, and even mica schist, yet the writer held, and in many cases proved, that they were simply various alteration stages of rocks which were once identical with modern basalts, excepting that in some cases they may have had originally a coarser crystallization, owing to a longer time occupied in solidification. *

The general bearing of the writer's conclusions referred to in the previous pages can perhaps be best understood by pointing out the different results arrived at by the mineralogical school and by the present writer concerning the classification and relations of some European rocks. In order to avoid any misunderstanding it is to be distinctly understood that the writer neither offers nor intends any criticism on the correctness of the determination of the rocks according to the methods of the mineralogical school, but simply desires to point out wherein the principles of classification followed by him would place the specimens in question. It is simply a question of correctness of principles, and not a question of the correctness with which those principles have been applied. There is no concern here with the determination of the mineral constituents or whether or not they occur in the rocks so as to give the mineralogical composition of rocks called dioryte, porphyryte, noryte, or what not, but the concern is to point out the rock from which the so-called dioryte, protobas, etc., has been produced by its alteration. The

* Geology of the Iron and Copper Districts, 1880, pp. 36–49, 70.

orthography of many of the localities given below is doubtful as the labels from which they were taken were not always remarkable for their perspicuity, and I have not now at hand the means of checking the errors.

Keratophyr.

The chief portion of the sections seen of this rock appear to be basalts altered to diabase; but a few of the Fuess slides have the structure of an altered acidic rock, felsyte, in which the quartz is secondary. All the specimens seen of keratophyr are in a highly altered condition.

Palæopicrytes.

Many of these are altered basaltic rocks of the gabbro type, but one from Marlesreuth appears to be an ordinary basalt.

Tephryte.

The tephrytes from Mittelgebirge, Bohemia, Gänseberg, by Garditz, Aussig, Sponeck, Neunlinden, Zewler, Sebusèin, and Kostenblatt appear to belong to the andesytes, as also do many others from Bohemia.

Teschenytes.

In general the teschenytes belong to the coarse-grained basalts, that is to the gabbro or diabase type, i. e., Boguschowitz, but some like those from Marklowitz, Söhla, and Craig Park are apparently altered andesytes.

Ophyte.

The rocks classed under this term are quite variable, but all seen by me belong to the basalts, and are now altered and properly fall under the varieties known as gabbro, diabase, melaphyr and dioryte.

Gabbro.

While in the majority of cases the writer would be in accord with the mineralogists in their classification of gabbros, yet those forms seen from Mt. Ferrato and Bombiana, Italy; Trodhu, Skye; and Inneres, Mull; he looks upon as andesytes bearing diallage.

Proterobas.

The great majority of rocks called by that name, like those

from Stiebitz and Rübeland, are diabases, but a few come under the name melaphyr, while some are altered andesytes.

Kersantyte.

These rocks appear to belong for the most part to diabase but some to gabbro.

Diabase.

The great majority of rocks commomly classed as diabase the writer would also place under that name as an altered form of basalt, but some he would prefer to consider as melaphyrs, as for instance those from Mallock, Darmstadt, Steinaer Thal, Konigsberg, and elsewhere. Some of the Darmstadt rocks are diabase however. A few of the so-called diabases are here regarded as altered andesytes e. g. that from St. Davids.

Melaphyr.

The chief portion of rocks known by that name I should class under that head, as a form of altered basalt, but some are probably altered andesytes like those from Cresta da Pell, Bubaure, Wildenfels, Neustadt, Kreuznach, and Wisendorf. The so-called melaphyr from Schneidemullerskopf is unquestionably an andesyte. *

Dioryte.

Nearly all diorytes seen are altered basaltic rocks, being simply further degrees of alteration in the diabase and melaphyr types. Some, however, like that from Dustenbrook, are altered gabbros; while that from Lac d'Ayatt is probably an altered andesyte. The same may be said of the mica diorytes, augite diorites and quartz-hornblende-diorytes, although rocks of an acidic character, and belonging to the hornblendic granites, have been sometimes classed under the quartz diorytes.

Basalt.

In the great majority of cases the writer would use the name basalt for the rocks which are usually so called by the mineralogists; but rejecting the divisions of older and younger, and arranging the varieties purely on the question of alteration and crystalline structure, he would prefer, if the variety names are to

* Decriptive Catalogue of American and Foreign Rocks, Boston, 1883, p. 14.

be used, to class as melaphyrs the rocks which he has seen from St. Helena and Palma, and as diabase that from the island of Skye.

Augite Andesyte.

As a division of andesyte, if this term is to be used, the writer would agree in regard to the rocks generally classed under that head; but some, like those from Rudigheim, are somewhat altered basalts, which might be called melaphyrs. The so-called augite andesyte from Puy de Louchaden is also a basalt, but little if any changed. The same may be said of the so-called augite andesytes from St. Elie, Horny-Turock, and Stoppelberg.

Hornblende Andesyte.

If the term hornblende andesyte is to be used to designate a division of the andesytes, so far as I have studied these rocks, there would be essential concord between myself and other lithologists.

Propylyte.

As claimed by the writer in 1879, this rock is an andesyte in which the groundmass and its porphyritically inclosed crystals are more or less altered, and in this view there is now essential agreement between myself and the majority of lithologists.

Hornblende Dacyte.

These rocks appear to be andesytes in which the groundmass and porphyritic crystals have been more or less altered, yet under the term dacyte are included many more or less altered trachytes and rhyolytes, as well as some unchanged forms.

Timacyte.

This is an altered andesyte of the hornblende andesyte variety, with the base altered.

Hornblende Porphyryte.

The majority of the rocks designated by this term belong to altered forms of andesyte, like those from Pic du Midi, Lugano, Angolo, St. Sigmund, Potschapel, Ilmenau, Thallichtenberg, Waldböckelheim, St. Margen, Pfremthal, and Longemer. Some, however, appear to be altered basalts, coming under the head of melaphyr, e. g., Steensfjord and Biella.

Diabase Porphyryte.

Some of these rocks are probably altered andesytes like those from Kohlschlag, Viezenna, Teufelstein b. Hof, Elbingerode, Kaisersbachthal, Tunnel b. Oberstein and Heringhausen. The majority, however, properly belong under the basalts, some being comparatively little changed, like the rock from Wolfstein b. Oberstein, while others are so altered that they are best classed under the head of melaphyr, e. g., Modum, Grenholmen, Holmestrand, Russberg, Ruskbey, Torno, Naretta, Mauchasher Grund, Schshelden, Dillenburg and Idar in Oberstein. A few are of the more coarsely crystalline type of altered basalts, coming under the head of diabase, e. g., Le Piera, Tyveholmen and Avanson.

Augite Porphyryte, or Augite Porphyry.

Of these, most are altered andesytes, e. g., Schaumberg, Klausen, Marathonisi, Bolan, Pfullschberg, Predazzo and Plauen. Part, however, belong to the basaltic rocks, e. g., some from Schaumberg, Ilmenau, Tunnel by Kern and Baldumstein.

Enstatite Porphyryte.

That the enstatite porphyrytes of the Cheviot Hills are andesytes has been strongly advocated by Mr. J. J. H. Teall, and that he is correct I feel sure from an examination of several series of these rocks and their sections, and their comparison with several hundred of the recent Cordilleras andesytes. In fact many of the Cheviot rocks are less altered than many of the recent Cordilleras ones. They belong mostly to the group of augite (enstatite) andesytes. Some of the Cheviot andesytes are much altered and now have the characters of that type of altered andesyte known as porphyryte.

The enstatite porphyrytes from Klausen appear for the most part to be altered andesytes, while that from Walschberg an der Höhe is also an andesyte.

Mica-Porphyryte.

The mica porphyrytes from Sadgardsä, Rocoaro, Ilfeld, Kreuznach, Ilmenau and Waldbökelheim are altered andesytes.

Feldspar-Porphyryte.

The rock from Kuhlberg is probably an andesyte.

Quartz Dioryte-Porphyryte.

The rock known by this name from Passer river is an altered andesyte.

Phonolyte.

This group of rocks is a difficult one, and in many cases the alteration has gone so far that the original nature can not be told. That from Alarve, Portugal, appears to have been formed from the alteration of a glassy rock of the andesyte type. The forms from Rochfort, Mont Dore, Puy de Dome, Toller Graber b. Wessler, Lischmitz, Kreuzberg, Bubenbad, Selberg, Roche Sanadoire, Grosspriesen, Tichlowitz, Aussig, Oderwitz, Heldburg, Calvarunberg, Horberg, Kapellenberg, Hohentwiel, Oberschaffhausen, Gönnersbohl, Eichberg, Teplitz and Hessenthall, are probably altered andesytes originally of a compact or glassy nature.

Other forms from Mont Dore are undoubtedly basaltic rocks, while specimens from Aschaffenburg, Teufelstein b. Rhön. Steinwand, Pferdekopf, Stein b. Pappenhausen, Milseberg and Hohenkrähen are believed to be altered compact or glassy trachytes. The forms from Schullberg, Milleschau and Selters are apparently from altered compact or glassy andesytes or trachytes but is is doubtful which. One from Stellberg is an altered glassy rock but to what species it originally belonged the writer has no idea.

Nephelinporphyr.

The forms from Fassathal, Mt. Mullato, and Viezenna are possibly altered andesytes.

Diabase Pitchstone.

The forms from Wolfstein and Weisselberg belong to the andesytes.

Dioryte Pitchstone.

These rocks appear to belong to the rhyolytes although they may possibly belong to the altered glassy forms of andesyte or trachyte.

Trachyte.

The form from S. Brorrosch is like the andesytes of Lassen's Peak, while those from the "Ausbruch de Epomeo im Jahr

1302," Ischia, and from the Plateau de Durbize I consider to be basalts. To the older and altered forms of trachyte belong very many of our porphyritic, gneissoid and friable gray granites, but others like the hornblendic and micaceous granites of Quincy and Rockport would appear to belong to the old altered and coarsely crystalline rhyolytes.

Augite Trachyte.

Many of these rocks are here considered to be trachytes but others like that from the "Arso Strom," Ischia, Perlenhardt, Brokasch and Alschberg are probably andesytes. Those from Pantellaria and Valle de la Cours are probably basalts but may be andesytes.

Hornblende Trachyte.

These rocks are chiefly trachytes, but some, as that from Rhöndorfer Thal, belong to the andesytes or basalts.

Mica Trachyte.

The mica trachytes seen apparently belong to the andesytes.

Trachyte Pitchstone.

The forms from Leva, Mt. Sieve and Tokaj belong, apparently, to the glassy andesytes.

Minette.

The specimens of this rock are in the majority of cases probably altered forms of andesyte.

Felsyte Pitchstone.

The forms from Grantola, Frejus, Burystall, Chemnitz, Meisen, Spechtshausen and Planitz, belong to the rhyolytes, part coming under the variety obsidian.

Quartz Porphyry.

The rocks classed under this term belong, as a rule, to the rhyolytes, of which they are altered forms.

Amongst other forms augite porphyry belongs in part to the basalts and part to the andesytes; schalestein to the poroditic variety of basalt; and augitite, pyroxenite and limburgite to the basalts. Amphibolite appears to be an altered basaltic rock, al-

though many of its forms are probably sedimentary. Labrador porphyry is an altered basalt coming generally under the head of diabase or melaphyr. Felsyte porphyry belongs in part under the altered trachytes and part under the altered rhyolytes. The nephelite and leucite rocks belong variously under the basalts, andesytes, and the more acidic rocks.

A far more extended series of names might be given but the above is sufficient to indicate the difference between the mineralogical method and the geological one. The one assigning the altered rocks to their particular position from the minerals that they at present contain, while the other endeavors to reconstruct the past history of the rock from its field relations or from the remains of its original composition or structure that may be left determinable in its altered condition.

I desire to extend my warmest thanks for aid and assistance given, as well as the opportunities offered for the examination of collections afforded me, to Messrs. Bertrand, Bonney, Brezina, Bücking, Cohen, Cole, Hermann Credner, Daubrée, Davies, Des Cloizeaux, Doelter, Fletcher, Foullon, Fritsch, Gümbel, Groth, Haushofer, Hirschwald, Hussak, Jannentaz, John, Judd, Kayser, Lasaulx, Lehmann, Lossen, Mallard, Meunier, Möhl, Osann, Renard, Rosenbusch, Justus Roth, Rothpletz, Rutley, Sauer, Tschermak, and many others. I especially wish to return thanks to Professor Rosenbusch, as no one who has ever studied with him can ever forget his patient, untiring, kindly assistance that he gives his pupils; as well as his devotion to their interests which leads him to place his time almost entirely at their free disposal.

It having been stated a number of times in the writings of others that my classification of rocks was based on their chemical composition, it is proper here to remark that such statements are entirely incorrect and have no foundation in fact. I have further distinctly stated in my "Lithological Studies" (p. 52) and elsewhere, that chemical analysis alone, as a general rule, is insufficient to furnish data for naming a rock; and I do not think a single instance can be found in my writings in which I have named any rock from its chemical composition alone.

As remarked before, my classification has been based upon the study in the field and cabinet, of rocks of every character and grade, by tracing out their relations, by comparing different

forms and by following them through their different degrees of alteration. Also by establishing the characters of the type or specific forms, when in their original or unaltered state, and tracing the gradual change and obliteration of these characters as the rock is more altered or metamorphosed.

The classification and arrangement were based on the field, macroscopic and microscopic characters of the rocks themselves, and not upon their chemical composition, as that composition has been known only in comparatively few of the rocks which I have studied and classified.

For example the diabases, melaphyrs, and diorytes were considered to be altered basalts, because there could be found in them in a more or less perfect state the characters of basalt as it is known in its purest unaltered type, while diorytes, in which even all the original basaltic characters had been obliterated by alteration, could also be provisionally referred to an altered type of basalt, owing to their having the general characters of other diorytes which could be proved to be altered basalts. Also the porphyrytes and propylytes were considered to be altered forms of andesyte, because they retained the partially obliterated characters of the unaltered andesytes. The same can be said of the relations of the felsytes and quartz porphyry to rhyolyte, or of serpentine to the peridotytes, etc., etc.

Now during the process of tracing the grades of alteration from the typical unaltered forms through their more highly altered, metamorphic, schistose, and fragmental conditions, it was found that unless some special accident had occurred like the removal of material or the importation of foreign matter, the chemical composition remained in the altered or fragmental states, within certain limits similar to the composition of the original rock. This fact, so far as it had then been confirmed was pointed out in 1879, and further it was shown in the lists of chemical analysis published in the "Lithological Studies," that this view was correct for the siderolytes, pallasytes, and peridotytes. So far as my researches have gone, it has practically been found that this view is correct for all rocks. Yet should the future show (as some of the later analyses of the Minnesota rocks appear to do) that this generalization concerning the chemical relations of rocks was incorrect, it would not affect or alter my classification in the slightest degree. The only cases in which I make any use

of the chemical composition are, first: in the effort to correlate all the characters of the rocks into a systematic and uniform whole; second: when the field relations, macroscopic, and microscopic, characters, combined or singly, leave the position of the rock doubtful, then the chemical composition is used to lend whatever aid it may, to the conclusions derived from the study of the other characters; third: in the case of certain rocks which have been so completely altered that the characters that they originally possessed have been entirely obliterated, then the chemical composition is used for what it is worth to indicate the probable original constitution of the rock from which the altered form was derived.

Yet I am perfectly well aware of the immense value of complete (Bausch) analyses of rocks if my generalization can be proved to be correct; and I desire and intend to continue the correlation of chemical composition of rocks with all their other characters as rapidly as the strength left, after attending to the "*brot und butter*" question, permits.

So far as I can prove that the chemical composition can be used in classification I may use it, but even then it would have to be subordinate to the other characters.

Many petographers consider that when the term *altered* is used concerning a rock it means it contains hydrated minerals, or is weathered, or in some way has lost its freshness. This is a view which should be corrected, as many of the altered rocks contain not a single hydrated mineral, and a large part of those forms which have been so changed that not a single one of the original minerals remains in them, are amongst the freshest rocks on the globe. How much hydration is to be expected when the original materials are altered to, or replaced by such minerals as quartz, feldspar, hornblende, or anhydrous micas? Yet these are the most common alterations when the change is complete, and the resulting rock is entirely fresh and anhydrous. The same freshness and want of hydration is also seen in numerous rocks, like the St. Paul peridotyte, in eulysyte, felsyte, quartz porphyry granite, syenyte, dioryte and many others; while in other cases every gradation can be seen between the perfectly fresh and anhydrous rocks and those which are weathered, or which are hydrous.

In view of the previous statement it will be no cause of sur-

prise to anyone that in my studies upon the Minnesota rocks, I have worked in the same manner as in the past — giving my attention chiefly to tracing out the alterations and relations of the rocks and their mineral constituents, rather than devoting my time to the usual discussion of the crystallographic, optical, and chemical characters of the contained minerals themselves.

THE PERIDOTYTES.

Classification.

The term *peridotyte* is employed by Professor H. Rosenbusch to designate all the pre-tertiary terrestrial rocks which are composed essentially of olivine or its chief alteration product serpentine with or without enstatite, diallage, augite, magnetite, chromite, picotite, etc., * i. e., to the older massive rocks free from feldspar.

The present writer later extended this term to include all terrestrial and meteoric rocks of similar composition and structure and to all derivatives of the same without regard to their age or state of alteration. †

The peridotytes are divided into a number of varieties according to their mineralogical composition, state of alteration, fragmental condition, etc. These varieties are sometimes determinable macroscopically and at others only microscopically, since the change in mineral composition oftentimes produces no equivalent change in external characters.

The classification of the varieties of peridotyte as proposed by the writer is as follows:

The peridotytes composed essentially of olivine are called *dunyte;* while those containing enstatite in addition to the olivine are designated as *saxonyte.* The term *lherzolyte* is applied to the forms composed of olivine, enstatite, and diallage, and *buchneryte* to the rocks whose essential constituents are olivine, enstatite and augite. For the variety composed of olivine and diallage the term *eulysyte* or *wherlyte* is employed. I have used the term eulysite in deference to the law of priority, as that name was given to the first described rock belonging to this variety al-

* Mikroskopische Physiographie, 1877, II, 524-545.

† The Iron and Copper Districts of Lake Superior, 1880, p. 65. Science, 1883, I, 127-130 Lithological Studies, 1884, pp. 84-194.

though it is far from being a typical one. The original wherlyte also is not a characteristic form of this variety, although more nearly so than the original eulysyte, but the term wherlyte used in rock nomenclature is later than eulysite. Wherlyte also comes in conflict with the well-known mineral wherlite which has an orthodox standing in mineralogy, and it seems to me exceedingly objectionable to incorporate into the forming science of petrography the names of rocks which are identical with those of minerals. However, if lithologists as a rule prefer the name of wherlyte, sanctioned as it is by the great authority of Rosenbusch, I am willing to conform to their usage. For the peridotytes composed of olivine and augite the term *picryte* is used.

The most common form of alteration of the peridotytes is to serpentine, but they are sometimes changed to talc or actinolite schists, and these names are used for the alteration varieties of peridotyte, so far as they properly belong under these designations. For the fragmental forms the terms *tufa* and *porodyte* are employed according as the fragmental rocks belong to the newer or older forms, i. e., the unaltered or altered state.

The classification of the peridotytes can then be tabulated as follows:

Peridotyte.

Mineralogical Varieties.	Alteration Varieties.	Fragmental Varieties.
Dunyte. Saxonyte. Lherzolyte. Buchneryte. Eulysyte or Wherlyte. Picryte.	Serpentine. Talc Schist. Actinolite Schist.	Tufa. Porodyte.

Macroscopic Characters.

The macroscopic characters of the terrestrial peridotytes are in general as follows, commencing with the dunyte variety:

They are of a grayish-green or green color, crystalline granular in structure, and usually contain more or less dark grains of

picotite or some iron ore disseminated throughout the mass. The first indication of change shows in the coloration, which passes from a green to a yellowish-green, yellowish, and to a yellowish or rusty brown. The rocks are more or less vitreous or greasy in lustre. With increasing alteration, a reddish-brown to grayish-brown color predominates; and this finally passes into a dark greenish-black to black compact rock, somewhat resembling the basalts, but of a duller color, of a more resinous lustre, and more compact, as well as of a higher specific gravity and less hardness. The crystalline granular groundmass of olivine or serpentine may or may not porphyretically inclose crystals and grains of enstatite, diallage, and augite. These minerals usually appear as greenish, grayish, or bronze-like crystals and grains scattered in the rock. They commonly weather to bronze-like, more or less cleavable and platy forms; and even on the fresh fracture of some specimens show in certain lights as an irregular network, brightly reflecting the light, and holding in its meshes the dark greenish altered olivine. The olivine groundmass when altered presents under the lens the appearance of yellowish or grayish granules cut and surrounded by a fine reticulated network of a darker material (serpentine); but when the change has progressed further, the groundmass becomes compact and apparently homogeneous. As the more highly altered states are reached, the variations in the macroscopic appearance become exceedingly numerous; so much so, that only a few of them can be mentioned here. The color generally is some shade of green, varying from a dark green or greenish black to a yellowish green. Sometimes it is reddish (brownish or cherry-red), owing to the state of its ferruginous contents.

Further, in the process of alteration there often results a fissile or schistose structure, giving rise to a pseudo-lamination. In part this seems to be owing to the segregation of chrysotile, serpentine, iron ores, dolomite, etc., in approximately parallel lines; and in this case the fissility is often only apparent and not real. Sometimes the schistosity seems to be due to pressure during the time of alteration. Occasionally the rock has a brecciated or conglomerate structure, owing to the vein serpentine or dolomite surrounding less altered portions of the rock. With the formation of talc or actinolite in these altered peridotytes, the transition to a true schist is evinced by various gradations, until a true talc-schist

or actinolite-schist results. These schists are greenish in their normal condition, but often through decomposition of the iron, become stained and present a rusty brown and gray aspect, closely simulating many mica schists. Owing to the production of dolomite, there result, in part at least, ophicalcytes and dolomitic limestones—the purity depending on the amount of alteration, and on the materials both carried into and removed from the rock during the process of alteration. These dolomitic limestones are usually gray, green, or yellow, but sometimes of quite a clear grayish-white color, and crystalline in structure. Of necessity, from the mode of origin of the peridotytes and their exposure to detrital agencies, various detrital or poroditic forms must result. Undoubtedly, when they are reconsolidated, it is exceedingly difficult to distinguish these true breccias, conglomerates, and sandstones from the pseudo-fragmental forms of similar structure that are produced in this rock species, as in every other, by the filling of fissures, or by the dissolving of portions of the rock and their replacement by other material, while interstitial portions of the rock remain *in situ*. The poroditic forms of the peridotytes, so far as now known, are all of a serpentinou character, having been greatly altered; but it is suspected, and in many cases claimed, that other forms are of like detrital origin; however, conclusive proof of this is still wanting.

The pyroxene minerals, when occurring, vary in amount of alteration from the porphyritically sprinkled bronze—or copper-like crystals to silvery-white, and to grayish and greenish forms, which in turn pass into patches of serpentine of a deeper green color and more compact texture than the groundmass, but which finally become completely blended with, and entirely lost in, the serpentine groundmass. Oftentimes the pyroxene minerals are replaced by greenish to whitish talcose material and talc scales. In the process of alteration, segregations of serpentine, dolomite, magnetite, chromite, etc., occur, giving rise to veins of serpentine (chrysotile) and to veins and nodular masses of dolomite and iron ores, lying in or traversing the serpentine groundmass. However dark the altered peridotytes may be in color, the thin splinters, as a rule, are translucent and transmit a greenish or yellowish light. The more or less serpentinized peridotytes are traversed by fissures, which are most abundant in those entirely changed to serpentine. The sides of these fis-

sures usually are polished or coated with serpentine, talc, etc. etc., forming "slickensides," which, it is conceived, may have some connection with the chemical alteration of the rock itself. Amongst the various forms produced by the extreme changes are a yellowish, more or less gummy-looking substance, and a grayish, yellowish, to chrome-green translucent serpentine. While these are oftentimes produced from the alteration of the rock *in situ*, they also appear to be formed by migrated serpentinous material, and in such cases to belong to the vein stones. These secondary massive products contain more or less iron ore in the form of chromite or magnetite. It is to these nearly pure serpentines, which result from the complete change or migration of the material, that the term *serpentine*, as it is used in works on mineralogy; properly applies. But from the general and microscopic characters of the material known as *serpentine* in lithology, it would appear that under that name is placed a mineral of variable composition, forming a series like feldspar or pyroxene, or else several distinct minerals are now so placed.

Microscopic Characters.

In giving the microscopic characters of the peridotyte it is best to commence with the dunyte variety as before.

This variety in the thin section in an unaltered condition consists of a clear granular mass of fissured olivine grains, which are either colorless or slightly tinged yellow or green. Sprinkled through the olivine mass are dark to brownish, opaque to translucent grains and crystals of chromite or picotite, and magnetite, as well as sometimes a few enstatite plates, either colorless or of a greenish hue. In the dunytes a gradual change to serpentine begins by the production of this mineral along the fissures of the olivine, forming a yellowish or greenish network. This change goes on until all the olivine grains are completely altered and only the network structure remains to tell the mode of alteration; while in some cases even the network structure is obliterated and no evidence is left to show the original character of the rock. In the process of the olivine alteration, the serpentine first formed along the fissures has a different color and structure from that later produced by the alteration of the interior portion of the olivine grains. In this way, by observing successive variations in the structure and color of the serpentine, two and

and sometimes three stages in the process of alteration are plainly to be seen. Thus while the mode of alteration is conspicuous in the earlier stages, the final result is to produce a pure, clear, homogeneous serpentine, of a uniform yellowish or greenish tint, or even colorless; in which no trace remains of the original structure to tell its derivation. These changes have been proven by following out the various successive steps in the process of alteration, in different portions of the same rock mass.

By the gradual addition of enstatite and other minerals, as well as by their subsequent disappearance, one passes over the various mineralogical varietal forms of peridotyte. The enstatite appears as a clear colorless mineral, or else as one slightly tinged with green. Sometimes it occupies a subordinate portion of the rock, then again it forms the chief portion, holding the olivine inclosed in and subordinate to it. The enstatite is sometimes feebly pleochroic, and shows a well marked longitudinal cleavage; the development of which, instead of forming a smooth fracture, usually occasions the tearing of a rough line, with stringy fibres extending from one side to the other. Besides the longitudinal cleavage, a cross fracture, at right angles to the principal cleavage, is often present.

The diallage possesses characters similar to those of the enstatite, and generally is undistinguishable from the latter except optically, but sometimes it shows two cleavages approaching those of augite, breaking the surface into rough irregular rhombs, which serve to distinguish the diallage in question from enstatite. Again the diallage not only exhibits the longitudinal cleavage, but also the well-marked prismatic cleavage of augite.

The augite is pale-yellow or brown, shows its characteristic prismatic cleavage and is sometimes feebly pleochroic. It occurs in grains and crystals, and sometimes incloses olivine grains.

The pyroxene minerals as a rule are less liable to alteration than olivine and frequently are determinable after the olivine has been entirely changed. The alteration of the enstatite usually begins to be conspicuous by the formation of a greenish product on its edges and along the cleavage planes. As the alteration progresses the pyroxene minerals are transformed into a yellowish or grayish serpentinous mass, which may show aggre-

gate polarization, or may retain that of the mineral which it replaces.

In the course of the conversion of the peridotytes into serpentine the original characters of the rock are gradually obliterated giving rise to a texture in the serpentine by which its origin can be determined.

But it is found on further change that patches appear in the serpentine which show no trace of the mode of formation of the serpentine, and that these patches spread until they gradually occupy the entire rock mass, yielding specimens whose microscopic structure gives no clue to their origin. In these extreme alterations a more or less schistose structure is oftentimes produced in the rock, and from this the writer conceives has arisen the view that serpentine rocks are derived from schists as well as from massive rocks. The absence of the reticulated or mesh structure in the serpentine, and the supposed want of chromite and picotite appear to be entirely due to the great alteration which produces a structure in the rock almost, if not quite, identical with that of the serpentine veinstones. The only apparent difference between the mode of formation of those serpentines that are homogeneous and the serpentine veinstones, appears to be that in one the molecular or chemical changes have taken place in the body of the rock, while in the other a transference to a new locality has been superadded.

A further step in the alteration of the peridotytes, as seen under the microscope, is the formation of more or less impure dolomitic rocks usually with included serpentine. In other cases the peridotic minerals are replaced by talc or actinolite giving rise to talc or actinolite schists.

Besides the above products of alteration there may be mentioned amongst the other secondary or alteration products hornblende, smaragdite, quartz, zircon, spinel, garnet, feldspar, chlorite, biotite, and various other micaceous minerals and carbonates.

An interesting group of minerals occurring in the peridotytes is that designated by Fouqué and Lévy as the *spinellids* * to include spinel proper, pleonaste, picotite, chromite, and magnetite. This term it would be well to extend to all the octahedral compounds of a protoxide and sesquioxide thus including magnesioferrite, hercynite, gahnite, franklinite, etc.

* Mineralogie Micrographie, 1879, pp. 409-420.

Of these the characters and relations of the picotite, chromite, and magnetite are of the most importance in the case of the peridotytes.

Under the microscope, picotite in its freshest state is a yellowish — or greenish — brown, clear mineral, which is subject to alterations causing the color to deepen to a darker brown or muddy coffee color and even to a black and opaque mass. The changed forms vary from a dull earthy mass to a crystalline-granular one which frequently contains more or less magnetite. Commonly the more altered the rock is to serpentine the less likely is one to find any of the translucent grains while the magnetite is the more abundant.

Chromite also in the thin section or in powder varies in color from a yellowish brown to a greenish brown and to deeper shades of reddish and coffee brown, or to a nearly or quite opaque mass. From the best evidence we have at present it is probable that picotite and chromite are different states of the same mineral, the term picotite being more commonly applied to the freshest conditions, and that of chromite to the more altered states, and to aggregations arising from the migration of the chromic oxide during the alteration of the peridotyte. As a further extreme in the alteration, a change to a more or less complete magnetite occurs, forming an apparent continuous series from the translucent picotite to the opaque magnetite.

Besides the above mentioned occurrence of magnetite this mineral appears to be formed in the peridotytes as follows:

In the course of the alteration of the olivine to serpentine much magnetite as a black dust or in aggregations of grains often occurs, particularly along the borders of the fissures, as one of the earlier products of the change; but later the magnetite is either collected into masses of greater or less size or else entirely disappears during the succeeding changes.

For a fuller discussion of the peridotytes, including serpentine, the reader is referred to the writer's Lithological Studies.*

While the peridotic rocks are far from being uncommon in Minnesota and the regions about Lake Superior, yet in the Minnesota sections that have thus far passed through my hands only one has been found to belong to this group. Still it has been thought best to give the preceding discussion in order to call

* Mem. Mus. Comp. Zoology, 1884, xi. Part 1.

attention to this series of interesting rocks in the hope that more especial attention may be given them in the future in the Northwest.

Special Description.

The only specimen of peridotyte found in the collection during this preliminary examination is No. 349, from the *Pipestone Rapids*, and belongs to the variety serpentine.

The hand specimen is a compact dark green rock traversed by veins of talc and dolomite, and coated in places by a limonitic deposit.

The section shows a pale grayish and yellowish green groundmass traversed by a reticulated network of magnetite, and cut by a dolomite vein. The magnetite preserves in part the outlines and fissures of the original olivine grains, while the groundmass itself is composed principally of a pale greenish isotropic* serpentine, talc scales, and fibres, and magnetite granules. The talc is in single plates and in aggregations of fibres. The general character of the rock is similar to the serpentines of Michigan, New Jersey, and Massachusetts.†

The figure of this serpentine given in plate I, Fig. 1, shows pale yellowish irregular masses of serpentine indicating the position of some of the olivine grains. These yellowish patches contain some iron ores, and are generally surrounded by colorless serpentine and irregular bands of magnetite granules. Some of the larger aggregations of magnetite are shown.

THE BASALTS.

General Description.

The tachylytic forms of basalt occur mostly as bands or fragments of rapidly cooled basalt. They generally show on the fresh fracture a pitchy to velvet black more or less lustrous surface. This weathers to a more or less greenish, yellowish, or reddish mass on the surface, while with continued change the mass of the tachylyte alters to an earthy brown color. In the

* Lithological Studies, 1884. pp. 79, 128, 129.

† Ibid, pp, 136–139, 156, 157, 159, 160; Geology of the Iron and Copper Districts of Lake Superior, 1880, pp. 60–66.

purest and least altered forms tachylyte does not seem to be magnetic, but in the devitrified or altered conditions magnetite is more or less abundantly developed. Microscopically tachylyte appears to exist in its typical state as a pure yellowish glass with a more or less brown tint. In proportion to the passage from the pure glass towards the condition of basalt, the darker the glass becomes and the nearer the tachylyte approaches the globulitic structure of the usual base of the unaltered basaltic rocks. The blackening of the glass is seen in connection with the crystallization of microlites in the magma and is in immediate contact with them. It further appears after solidification when incipient devitrification takes place, the glass then becoming darker and even black. The passage from the tachylytic stage to the basaltic stage proper takes place on account of the greater time of solidification of the basalt which allows microlites and grains of feldspar, augite, and magnetite to be irregularly formed through the glass. The number of these crystallizations increase in abundance and amount until the rock passes into a true basalt with an intensely dark interstitial globulitic base. By the process of secondary devitrification the tachylyte becomes discolored, and spherulites of a dark brown to black color appear. Feathered forms occur, and finally lighter colored spherulites are formed, while the glass itself is more or less completely devitrified and affects the polarized light, until a transition is made to those common altered forms of basaltic glass or tachylyte,* including the glassy diabase of Rosenbusch, which are here grouped under the name of zirkelyte, in honor of one who has done so much for petrography. In the crystallization of the tachylytic glass from the cooling magma, the minerals that crystallize out are dependent upon various causes, the principal one probably being the rate of cooling. Feldspars, usually, plagioclase, are among the first to separate out, while olivine or augite may be wanting. Magnetite grains are generally present but not always. The absence of the corroded or foreign crystals, like olivine, in the tachylyte is probably due to the fact of their being borne towards the centre of the dike or lava flow as a point of less resistance, as suggested by Judd and Cole. †

* Am. Jour. Sci., 1884 ,(3) xxviii, 94-96; Proc. Bost. Soc. Nat. Hist, 1877, xix, 232, 233; 1878 p. 315. Geology of the Iron and Copper Districts of Lake Superior, 1880, p. 44.

† Quart. Jour. Geol. Soc., 1883, xxxix, 454.

The glassy forms of basalt, which have been variously called tachylyte, hyalomelane, hydro-tachylyte, sideromelane, basalt-glass, etc., appear to be due simply to the rapid congealation of a basaltic magma, which with a longer time for solidification would have assumed the structure of ordinary basalt. Further they form simple narrow bands and crusts on the borders of dikes, surfaces of lava flows, and in other positions when the solidification has been sudden, but do not seem to exist as large masses in connection with modern lava flows, except in some cases as the Sandwich Islands. That glassy lavas similar to those of Kilauea were formerly erupted in Newfoundland* has been already pointed out by the present writer.

While there appears to be no need of distinguishing these basaltic glasses as distinct species, as has been done, or even to separate them as varieties of basalt, yet the habits and customs of lithologists are so strong, that it is thought best to designate here all these unaltered glasses by a variety name. Of all names used that of tachylyte appears to be the oldest and best established, while the other designations would seem to have been in a great measure abandoned.† Hence tachylyte will here be used simply to designate the unaltered glassy basalts in general.

The more altered forms of basaltic or tachylytic glass are those, which, as a rule, are the pre-tertiary or the older forms of most lithologists, and they have here been grouped under the name of zirkelyte, as before stated. The least altered form studied by the writer is a perfectly black rock which in the thin section is composed of a greenish, yellowish, and dark brown glass, which in places is more or less devitrified, tending to assume a spherulitic structure, and slightly affecting polarized light. It shows a well-marked fluidal structure and contains a few lath-shaped plagioclase crystals, magnetite, and a few pseudomorphs after olivine which are for the most part colorless and show fibrous aggregate polarization. The presence of the olivine may be accounted for here by the fact that the glass occupied the entire width of the dike.‡

* Am. Jour. Sci., 1884, (3) xxviii, 94-96.

† Rosenbusch Mikros. Phys. 1877, ii, 444-447. Neues Jahr. Min. 1882, ii, 1-17. Penck, Zeit Deut. Geol. Gessell., 1879, xxxi, 521, 522. Judd and Cole. Quart. Jour. Geol. Soc., 1883, xxxix, 444-465.

‡ Proc. Bost. Soc. Nat. Hist., 1878, xix, 315.

Other forms of zirkelyte are grayish rocks which in the thin section show a grayish altered glass that affects polarized light but little. They have sprinkled through them lath-shaped plagioclases, pseudomorphs after olivine, magnetite grains, and secondary crystals of pyrite. The feldspars are partially altered to dirty green viridite or colorless micaceous scales.

In other cases the section shows that the glass has been divitrified to a finely fibrous and globulitic grayish brown material, which shows aggregate polarization. This form contains greenish pseudomorphs after olivine; and also feldspar crystals, which for the most part have been replaced by greenish chlorite scales and calcite. While part of these feldspars show by their form that they were once plagioclases, they give no evidence of this fact in polarized light, but show complete aggregate polarization.

Other forms are fine-grained greenish gray rocks weathering to a brown color and holding small porphyritic feldspars. The groundmass is produced from the devitrification of a former basatic glass and is now composed of a dirty gray fibrous, and granular mass. This groundmass encloses numerous minute lath-shaped plagioclase crystals, also virditic scales and ferruginous granules. A few augite grains and some pseudomorphs after olivine also occur.

Still further altered specimens contain calcite and delessite (?) amygdules besides pyrite. In the section the groundmass is much decomposed and the feldspars are in part obliterated by a spherulitic structure due to alteration. The fibres of the spherulites show the characters of amphibole. A number of pseudomorphs after augite, etc., occur. These pseudomorphs are composed of quartz grains implanted on the walls, while the interior portion is filled with a dirty green delessite (?). The delessite and viridite are irregularly scattered throughout the groundmass.

In the form of basaltic rock nearest that of tachylyte the rock is usually brownish black and contains a few secretions of feldspar or olivine grains. In the sections we have a dense black globulitic base holding crystals of feldspar and augite, with the grains of olivine, although in some cases the latter are wanting. The globulitic base is evidently the partially devitrified tachylytic glass as is rendered evident by tracing in the same hand

specimen the gradual passage from one to the other; also as that passage is seen to extend from the surface towards the interior it is known to be connected with the greater length of time occupied in solidification.

As we pass on towards the still more slowly cooled forms the globulitic base becomes less and less abundant, and the mineral secretions more and more so until they pass into the anamesitic type. The rocks of this type are generally of a black, brownish-black, grayish-black or reddish-brown color, and are usually somewhat porous and cellular. The cells are generally spherical or flat elliptical depending upon the manner and rate of motion of that particular part of the rock at the time of its solidification. Fluidal and laminated structures are also occasionally seen, the latter of which gives to the basalt a schistose appearance. Grains of olivine and rarely grains of quartz and feldspar occur. Some of these basalts, particularly on the upper surface, are scoriaceous and of a reddish-brown color, caused by the change of the iron, during the cooling stage, from the ferrous to the ferric state; although in some cases the change may have taken place subsequently. Under a lens the sections show a brown or black groundmass with inclusions of feldspar and olivine or augite. Under the microscope the sections are seen to be composed of a globulitic base holding feldspar, augite, and olivine, with magnetite. The feldspar has the form which I have called basaltic, i. e., small elongated triclinic twins, several times longer than broad, and with fringed and step-like ends. These feldspars are frequently of unequal width, on account of the inclusion of the base in a wedge-shaped mass penetrating one end of the feldspar along the line of twinning. Again little masses of the globulitic base are seen scattered all along this plane of twinning. These feldspars are usually very clear but their boundaries are often indistinct, on account of the interlacing of the feldspathic material with the globulitic base and their gradual passage into one another.

In the midst of these lath-shaped plagioclase feldspars some larger tubular forms occur, part of which are triclinic, but some of them are probably sanidin. The olivine is in grains and rounded crystals which have generally been attacked by the molten magma, tongues of which penetrate into the olivine substance. The olivine is often blackened on its edges, and some-

times throughout the entire mass; in the latter case it is seen to be chiefly composed of minute grains and fragments of opacite or magnetite; aggregations of these grains are not infrequent, and every gradation can be traced from the almost unchanged olivine, to these little heaps, that are the remnants of the destroyed olivine. The crystals are frequently broken and the broken parts occasionally blackened on every side, while more or less rounded fragments are disseminated throughout the ground-mass. That the olivine has been heated and attacked by the molten magma is shown only not by the characters given above, but also by the fact that the blackened crystals, when found of sufficient size to be completely freed from the ground-mass, are quite strongly magnetic, the same as some olivine is known to become on heating it before the blowpipe. May not this attack of the magma on the olivine be in some measure the cause of its rapid and varied alteration, to which it is subject after the consolidation of the rock? Only occasionally does the olivine bear evidence of crystallization from the magma, while the characters given above prove that it is foreign to its present position in the great majority of cases. These characters belong to the olivine of the old basalts (melaphyrs) as well as to the recent ones, and is one of the strong proofs of their identity. The derivation of this olivine is of course a matter of uncertainty; it can be considered to be derived from fragments torn from older olivine bearing rocks, or else that the lava, in part at least, was derived from the remelting of older basaltic lava, that had cooled to the point of crystallization at * the depth at which it then existed. Owing to the widespread occurrence of the olivine, and its possession of these characters in the earliest (Azoic) as well as in the latest of the finer grained basaltic rocks, coupled with its almost complete absence from the more acidic rocks, and from its possessing the same character when it occurs in them, leads me to adopt the later view for most of its occurences. † The augite is usually in rounded grains but occasionally in crystals; it becomes more abundant as the olivine diminishes and in the more coarsely crystalline basalts (dolerytes and diabases) as a

* The generally adopted explanation of M. M. Fouqué and Lévy for the corrosion of the crystals of olivine, hornblende, quartz, etc., does not appear to the writer to be a correct one.

† Rosenbusch, Mikros. Phys., 1877, ii, 433; Lehmann, Verhandl. Natur. Bonn., 1874, xxxi, 6; Von Buch, Beschreibung der Canarischen Inseln, p. 303; Scrope, Volcanoes, 2d edition, p. 119; Bischof, Chem. Phys. Geol., 2d edition, ii, 687-690; Genth, Am. Jour. Sci., 1862, (2), xxxiii, 202.

rule it entirely replaces the olivine. It is probable the olivine being dissolved in the magma has its substance mixed, with a greater or less degree of thoroughness, with it and gives rise to the formation of augite; when, however, the dissemination is imperfect, the olivine sometimes recrystallizes.

Part of the iron in the olivine probably goes to form opacite or magnetite, as under the microscope it is impossible to determine whether the blackened particles of olivine belong to opacite or magnetite; opacite being only a name* given to indicate the dark ferruginous particles derived from the decomposition of minerals. In all cases opacite approaches more or less near to magnetite, if not quite to it, according to the perfection of the removal of the chemical constituents except the iron; and much of the disseminated magnetite has probably been derived in this way. It is well known that part of the analyses of magnetite, and most of those of menaccanite show the presence of magnesia in these minerals.†

Quartz occasionally occurs in inclosed rounded crystals and fragments, probably derived from other rocks, as its comparative rarity, and its general occurrence in those basalts, that from their scoriaceous or other characters seem to have formed the surface of the flow, would indicate this. The quartz is, however, partially dissolved and must have tended to make the magma more acidic. It is in general of the same character as the quartz in the quartzose varieties of the trachytes, andesytes, and so-called propylytes, except in the cases in which it is a product of alteration or infiltration, or when quartz-bearing basalts have been mistaken for these rocks.‡

No natural division exist between the compact and the anamesitic and doleritic varieties of basalt, the distinction being a purely artificial one; and these terms would not be employed in this paper, were it not for their common use in many works for the purpose of designating the coarser grained basalts. The anamesitic and doleritic varieties are usually of a gray, brown, or reddish-brown color, often cellular, somewhat crystalline, and in general contain more or less olivine visible to the naked eye;

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* Vogelsang, Zeit. deut. Geol. Gesell., 1872, xxiv, 530.

† Rammelsberg, Handb. Min. Chem., 2d edition, pp. 132, 151; Bischof, Chem. Phys. Geol., 2d edition, ii, 938; Dana, Mineralogy, 1868, pp. 144, 150; Lithological Studies, p. 153.

‡ Bull, Mus. Comp. Zool., 1879, v, 279–287; Proc. Bost. Soc. Nat. Hist., 1881, xxi, 260–268; 1883, xxii, 422, 423.

quartz also is sometimes seen in these as well as in the more compact basalts, in the same rounded grains and fragments. The thin sections are usually gray or brown in color, and the constituent feldspar, olivine, and augite can be readily seen by the aid of a glass.

If we examine with the microscope a series of slides beginning with the glassy basalts, and passing towards the dolerytes, we shall observe a gradual change in our series: a brownish glass replaced by a dark globulitic base holding feldspar, olivine, and some augite; again this base gradually diminishes in quantity, as the rocks become more and more crystalline, and the augite and olivine gradually assume the functions of the base. The olivine grows less in quantity and the augite more abundant, until it replaces all or almost all of the olivine. As the base lessens in quantity, the crystals of feldspar generally become arranged somewhat at oblique angles to each other, so that they hold between them cuniform masses of the base, olivine, augite, and magnetite: sometimes one of these substances alone, and at others all together. This divergency of the crystals could hardly take place except in a somewhat quiescent mass, which as well as the coarser crystalline structure, would indicate that these varieties are caused simply by the greater length of time in cooling; other causes may have intervened, sometimes, of which at present we know nothing. The augite in the more coarsely crystalline of these rocks seldom is in well-formed crystals, but is in general in irregular masses dissected by the feldspar, and these masses are usually made up of augite grains and irregular forms.

The olivine remains the same in character except perhaps it shows more of the serpentinous and ferruginous decomposition so characteristic of this mineral.*

Sanidin is more abundant, and the magnetite is in larger grains and in long dash-like forms that are supposed to be quite characteristic of titaniferous iron. †

Some of the basalts contain a felty base but it is unlike the felty base of the unaltered andesytes, which is so characteristic of them; it occupies a subordinate position in the rock, and is probably a fibrous devitrification or alteration product of the

* Senft, Die Felsgemengtheile, 1868, p. 555.
† Hawes, Lithology N. H., 1878, p. 40.

common globulitic base, as it is only seen in somewhat altered basalts.

The only cases in which this base will be confounded with that of the andesytes is when the andesitic felt has been somewhat altered, in which case the other characters must help us to decide.

The chief characters of the basalts are their generally uniform black, brown, gray, or reddish groundmass containing usually but few porphyritically inclosed minerals except olivine, with occasionally some feldspar and grains of quartz; sometimes they are cellular with spherical or flattened cells. Sections of the rock under the loupe are of lighter color than the rock, showing a groundmass containing olivine, rarely augite, and in the more coarsely crystalline basalts, feldspars, which generally lie obliquely to one another. Under the microscope the especial characters are the general coarseness and roughness of the section as a whole, owing to its constituents and their arrangement; the globulitic base; the occurrence of olivine; the basaltic form of the feldspar; and in anamesitic and doleritic varieties, the divergency of the smaller feldspars with the wedge-shaped masses between them of base, olivine, augite, and magnetite. This structure can be considered as an ophitic one passing into a granitic one, as the more perfect it becomes the less of uncrystalline material is left and the nearer does it approach the structure of granite; and if we could obtain specimens at any considerable depth we should probably find that they had entirely crystallized, its last remaining portions forming cuniform masses of quartz the same as is now seen in some of our coarser gabbros, when that quartz is not secondary. Other characters are the great abundance of plagioclase with the corresponding rariety of sanidin, the presence of magnetite in crystals, and grains or droplets of augite and olivine in the groundmass. In the doleritic and anamesitic forms a characteristic feature is the presence of irregular masses of augite composed of one or many individuals or grains that are cut through by the divergent feldspars. There is no one of these features but may be absent from a section, and in that case the decision must be made upon the others; while in the very dense, or altered basalts, comes the greatest difficulty in the classification. The globulitic base is here the most important character, so far as my observation has gone, as it is never seen fully de-

veloped in any rocks except basalts, and further it is never entirely wanting in any true and unaltered specimen, * while any of the other characters may fail in either direction.

The order of crystallization of the minerals in basalt is generally the following: the olivine, quartz, and probably some of the magnetite if not all of it, the picotite, and rarely some others are in general of prior origin; while the products of the crystallization of the lava are the feldspar, augite, occasionally a little olivine, and perhaps magnetite. The crystallization of the augite and feldspar was contemporaneous as regards the section as a whole but at any one point, sometimes one and sometimes the other preceded; generally, however, the feldspar was the first separation.

The basalts are subject to alteration to a greater extent than any other modern volcanic rocks; the alteration diminishing in amount and variability, in order from basalts, andesytes, and trachytes on to the rhyolytes, the amount and variation of the alteration being proportioned in some degree to the silica present. The color of the altered fine grained basalts is generally a brown, wood and reddish-brown, red, brownish-yellow, greenish, etc., the shades being usually dull. The various alteration products are: Viridite, glauconite, delessite, saponite, serpentine, the various zeolites, palagonite, and many others of the interminable and indeterminable hydrous silicates, feldspars, epidote, hornblende, quartz, chalcedony, muscovite, biotite, opal, anhydrous and hydrous ferric oxide, calcite, etc., etc., these alterations giving rise to many names and so-called species of rocks, as well as to some pungent literature. The cellular basalts have their cavities more or less filled with mineral matter, giving rise, when the change has gone far enough, to amygdaloidal rocks like the amygdaloids in the vicinity of Boston, and from Lake Superior. Further, from changes that occur in the groundmass pseudo-amygdaloidal forms arise, and it is doubtful if these forms can in many cases be distinguished from the true amygdaloids formed from the filling in of pre-existing cavities. Numerous examples of this can be seen in the vicinity of Boston, where the rock has been quarried away leaving only the compact old basalts (melaphyrs), when the quarries were abandoned; which compact rock later began to decay and alter, giving

* Except in Nos. 196, 197 and 198 described by Zirkel, Microscopical Petrography, 1876, pp 99, 100.

rise to a pseudo-amygdaloid filled with green earth, which with our present knowledge, could not be distinguished from a true amygdaloid, if its origin had not been known. The writer has observed this change, especially in one quarry, which of his own knowledge, he is aware had not been abandoned over five years, and he believes that in this way, by alteration, many of the rocks called amygdaloids became possessed of this structure, * further, that as the mineral matter filling pre-existing cavities was derived from the surrounding rock mass, the true and pseudo-amygdaloidal characters are usually combined in the same rock. The specimens are usually decomposed to some extent, often wackenitic, sometimes porphyritic, schistose or foliated and possessing that multiplicity of characters to the eye that have perplexed geologists since the science of rocks began to be studied; these characters are so various that they must be traced out in the special descriptions of such rocks, for no general description will cover all cases.

The sections to the unaided eye, or under the lens, present as variable characters as the hand specimens, being of various shades of brown, red, green, and yellow, and are compact, amygdaloidal, porphyritic, foliated, or earthy, like the rock from which they were derived. The microscopic characters of the rocks and of the sections are to a greater or less extent basaltic, depending upon the amount of alteration, and they form with the unaltered basalts a continuous series.

Under the microscope the sections show the characters of basalt with more or less obliteration of these characters depending upon the amount and kind of alteration.

The base generally suffers first, becoming devitrified and yielding quartz, feldspar, viridite, palagonite, and other alteration products; the groundmass next undergoes change, yielding quartz, chalcedony, opal, feldspar, epidote, serpentine, palagonite, viridite, chlorite, zeolites, calcite, etc., etc.; and the porphyritically inclosed minerals also suffer to a greater or less extent their characteristic alterations. The olivine is replaced by serpentine, quartz, calcite, viridite, and the ferric oxides; the augite by viridite, chlorite, biotite, and hornblende, the feldspar by viridite, kaolin, quartz, and other substances.

* Wadsworth, Proc. Bost. Soc. Nat. Hist., 1877, xix, 283; Pumpelly, Proc. Am. Acad., 1878, xiii, 269

These changes often progress together, the olivine, however, usually being altered in basalts which are otherwise unchanged. The feldspar with occasional exceptions is the last mineral to undergo change in these rocks. The determination of altered basalts depends of necessity upon the retention of some of the original characters; and upon the knowledge that is possessed by us of these and of the alterations to which basaltic rocks are subject. The basaltic character and arrangement of the feldspars are usually the last characters to be obliterated; although the pseudomorphs after olivine, showing the effect produced by the magma, are very important distinctive characters when they are present; further, the minute rounded grains of augite and of olivine, when present, are also important proofs. The less altered the rocks are and the more characters of unaltered basalts they possess the stronger is the proof of their identity. Chemical analysis made upon properly selected and thoroughly studied specimens would probably aid much in establishing laws for their determination. To this class of basalts where the alteration has gone far enough to affect the macroscopic characters the term melaphyr has been given by the writer, for the reason that to these rocks this name seems to have been almost universally applied, in spite of the numerous definitions that have been given to it.

The chemical and microscopic analysis of melaphyrs, as well as the field relations, that have been published, indicate, that excepting some altered andesytes, which have been called melaphyrs, the term melaphyr is generally confined to the group, of fine grained altered basalts, even if it does not include all of them. Melaphyr I define, therefore, to be simply an altered and, therefore generally old, compact basalt. Under melaphyr I include also some rocks of a basic nature, whose groundmass is principally hornblendic, micaceous, or chloritic, these minerals arising in both cases from alteration; as a study of the characters of these rocks leads me to believe that they are altered basalts, although it is possible that they are altered andesytes, a question which chemical analysis at some future day may settle. These forms have usually been classed as diorytes (a term much more abused at the present time than melaphyr ever has been), also as hornblende, mica, and chlorite schists, forms which the writer has claimed for years the old basaltic rocks were altered into. The

alteration of the more coarsely crystalline of the basalts; the anamesytic and dolerytic varieties, gives rise to rocks colored various shades of green, gray, or brown, sometimes weathering to an earthy or rusty brown, and showing jointing, closely simulating stratification and lamination. Some of these, like the melaphyrs, have a spheroidal disintegration. In general these rocks like the melaphyrs can be distinguished in the field as well as in the hand specimens by the skilled petrographer on account of the alteration characters they possess; but this does not entitle them to be considered as a distinct species of rock, but only as an altered variety of basalt to which they belong. The products of alteration in these rocks are chiefly pyrite, quartz, mica, epidote, hornblende, viridite, chlorite, prehnite, the zeolites, and calcite. As the more commonly occurring of these products are of a greenish shade of color, so in these rocks some shade of green predominates, as the term greenstone so commonly applied to them shows.

When the alteration has progressed far they resemble sometimes and even become chlorite schists, hornblende schists, mica schists, greenish felsytes, greenish limestones, etc. To these altered basalts in accordance with the general custom the name diabase is given, a name holding the same relation to melaphyr that doleryte and anamesyte do to basalt when this latter term is used in its original meaning for the compact basalts. That diabase and melaphyr are but the coarser and finer crystalline states of the same rocks was proven by the writer both from geological and microscopical research in the case of the intrusive rocks in the vicinity of Boston.* In one case the edge of a dike had the characters of a melaphyr and the interior those of a dioryte, while the dike is believed to be beyond a doubt an old basalt. In the coarser parts of some of these diabases hornblende instead of augite abounds, which hornblende is an alteration product chiefly of augite, showing that dioryte and diabase are geologically the same, which the writer has believed to be universally the case with basic diorytes in which the hornblende is an alteration product; as it always is except in the case of a few diorytes which belong to the old andesytes. Thin sections of these rocks show usually green or gray colors, generally both together, and under the lens the feldspar is seen to

* Proc. Bost. Soc. Nat. Hist. 1877-78, xix, 223-237, 309-316.

predominate; its color is generally a grayish or greenish white, the crystals being usually divergent and holding between them angular and irregular masses of magnetite and menaccanite, also augite, chlorite, viridite, and other minerals; the chlorite, viridite, and hornblende coming from alteration of the rock and giving rise to its green color. The sections, when examined under the microscope, show to a greater or less degree, according to the amount of alteration, the characters of the dolorytes and anamesytes as given on previous pages. The feldspar becomes changed to some extent, often losing all traces of its polysynthetic twinning, sometimes showing aggregate polarization from the alteration to quartz, mica, viridite, chlorite, calcite, etc.; but it is very rarely the case that the original structure and arrangement of the feldspars are entirely obliterated. In the non-porphyritic diabase, the angular spaces left by the feldspar are filled by the original constituents of the basalt or by their alteration products.

The base, part, and sometimes all, of the augite are replaced by viridite, chlorite, mica, hornblende, epidote, prehnite, quartz, calcite, and some other products, showing fibrous or aggregate polarization; but sometimes, as in the case of epidote, prehnite, and quartz, showing the polarization characteristic of an individual crystal. The titaniferous iron is also frequently altered to a grayish white product of indefinite nature called leucoxene.* In some cases the diabase closely resembles chlorite schist when it has not actually been metamorphosed into that rock, while it has probably been mistaken for it by geologists many times. The characters of basalt that remain longest in the diabase, are the presence of the remains of augite cut generally by the divergent feldspars; the lath-shape and divergency of the feldspar; and the titaniferous iron with its alteration product. As pyrite in the highly altered diabases yields a product of similar microscopic characters to those of leucoxene, care is to be taken not to confound the two.

Belonging to the diabases, as the writer believes, or has sometimes proved, are certain porphyritic crystalline rocks that have suffered much alteration and are usually classed under the head of dioryte. The general habit of these rocks is like the diabases into which they have often been traced in the field,

* Rosenbusch, Mikros. Phys. 1877, ii, 336; 1885, i, 332, 333.

showing, however, long hornblendic crystals which under the microscope are found generally to be alteration forms usually uralitic, but oftentimes of the common brown form; some sections showing no augite, while other sections of the same specimens often contain considerable augite, altered along its edges and fissures to hornblende. The specimens contain considerable alteration quartz, and the feldspar has its primary characters nearly, and often entirely, obliterated. The characters of these rocks are so obscure much doubt must remain regarding the affinities of some of them, until their relations are more carefully studied in the field and less altered and more characteristic specimens selected by the petrographer. Some of these rocks may belong to the altered andesytes.

Questions of this kind are very difficult, but it is the duty of the lithologist to do all that he can to solve them with the material he has at hand. The more coarsely crystalline of the old basalts contain foliated pyroxene with or without olivine, and are known as gabbros. They can not be definitely separated from the diabases and form part of the same continuous series. The minerals occupy the same relative position in these rocks that they do in the diabase, the alteration products here being principally hornblende, mica, quartz, serpentine, magnetite, and saussurite. The alteration of the feldspar to saussurite gives rise to the altered basalt known as euphotide, a name which it would be well to dispense with, together with numerous others that only lead to confusion in the science.

FRAGMENTAL BASALTS.

Tufa.

The fragmental basalts are often mixed with other clastic materials and also suffer the same alterations as the parent rocks. In the mixed clastic tufas it is largely a question of predominence of basaltic over any other material that causes them to be placed under this head. The color of the basaltic tufas is generally grayish, reddish or dark brown; in texture they vary from a compact to a friable mass composed of coarse or fine fragments.

Each case requires for it an individual description; while in the thin sections the basaltic fragments show those characters

belonging to basalts, and the other fragments, the characteristic of the rocks to which they belong, thus enabling the skilled observer to determine each fragment large enough to contain any groundmass of the parent rock.

The student's success in the study of tufas must depend on his knowledge of the massive rocks and of their alterations.

As remarked above the tufas are subject to the same alterations, under like conditions, that their parent rocks are, and these alterations are to be studied in like manner. When the change has proceeded far enough to induce characters in the fragments, like those of melaphyr or diabase or even still greater, or if the fragments were originally derived from altered basalts, the resulting rocks are here classed as

Porodyte.

The poroditic rocks belonging to the basalts are usually of a gray or green color with a massive or schistose structure. They are to be distinguished by their fragmental character, often only determinable under the microscope. The rock species from which they were derived is perhaps never determinable except in the thin section and then often only with difficulty, depending upon the amount of alteration to which the specimens have been subjected. The individual fragments are to be distinguished by their retention of the same characters that the alteration varieties of the basalts have, or the retention of the characters of the other rocks, from which any of the fragments may have been derived; the earthy cementing material formed by the comminution of the fragments is usually of an indeterminable nature, and its composition can only be inferred from the included fragments. Certain of these porodytes resemble macroscopically highly altered and very compact diabases, with a conchoidal fracture, and have given great trouble in the field because their petrological relations and contained fossils indicated that they were sedimentary rocks, while their resemblance to diabase, from which they were derived, was thought to prove the sedimentary origin of all diabases. Many of the porodytes are altered to hornblende and other basicschists in which traces of their origin remain, usually in the form of the augitic fragments. From the published analysis it can be inferred that

most of the hornblende and chlorite schists, as well as some mica schists, which are not altered eruptive rocks, have had a like derivation, but that is a subject for further careful investigation. As the difference between an altered basaltic and andesitic rock is but slight, the distinction between the fragmental porodytes derived from these two species is a matter in many cases of very great difficulty and uncertainty, depending oftentimes upon the form of the augite crystals and fragments, together with their inclusions; but occasionally the augites show the wedge-shaped form and dissection so marked in the diabases. The European basalts are generally more altered than those from the western part of the United States, the globulitic base being obliterated except in those from active volcanoes, as far as I have seen. Many of these European basalts would fall under the head of melaphyr or diabase as they have been defined in this paper; as would probably nearly all those described by the English lithologists. The same greater age and alteration seems to hold good for all the volcanic rocks on the Atlantic slope of the continents, with the exception of those from active volcanoes; to the Pacific slopes we are then to look for the key to the petrographical history of the globe, which will need to be supplemented by the study of the older and more altered types of the Atlantic drainage slopes. In truth the writer does not believe that any petrographer can do satisfactory work upon the older rocks, until he is thoroughly conversant with the modern and unaltered forms, and is able to trace the gradual passages and changes of the latter into the former, as both, instead of being distinct types, are, according to the present writer, one and the same, the only difference between the ancient and modern forms being due to the alteration of the former, and to a more coarsely crystalline texture of the latter, owing to the greater depth at which the rock solidified, and the longer time occupied in consolidation.

Taking the various forms which are assumed by the basaltic rocks both in their original state and under conditions of alteration the various modifications can perhaps best be classified as follows:

Unaltered Structural Varieties.	Unaltered Mineralogical Varieties.	Altered Structural Varieties.	Altered Mineralogical Varieties.	Fragmental Varieties.	Altered Massive and Fragmental Varieties.
Tachylyte.	Basalt.	Zirkelyte.	Leucityte.	Tufa.	Argillyte.
Basalt.	Leucityte.	Melaphyr.	Nephelinyte.	Porodyte.	Phonolyte.
Anamesyte.	Nephelinyte.	Diabase.	Dioryte.		Granulyte.
Doleryte.		Gabbro.	Syenite.		Amphibolyte.
			Granite.		Epidosyte.
					Eklogyte.
					Chlorite Schist.
					Hornblende Schist.
					Actinolite Schist.
					Steatyte or Talc Schist
					Mica Schist.
					Gneiss.

The classification given above of the basalts differs somewhat from that given by the author in 1879. At that time peridotyte was placed with the basalts, and he did not employ in the classification so many names under the varieties as here, for the reason that while he was then aware of schistose and granitoid varieties amongst the altered forms of basalt he had the idea that it was better to class these forms under melaphyr, diabase, gabbro, etc., a view which in the present state of science it is impracticable to carry out, and will be for many years, until petrographers become more familiar with the changes that rocks undergo subsequent to their consolidation.

Many more names could have been employed to indicate the alteration or even the mineralogical varieties than have been given above, but that seemed unnecessary. The use here of any term like granite does not imply that all granites are altered basalts, but only that some rocks called granites, etc., are altered forms of basalt.

The term basalt is here used as the specific or generic term instead of doleryte as suggested by Allport and Dana, and em-

ployed by myself in 1877. The cause for this change is the fact that the majority of petrographers use the term basalt as the generic term, therefore it is better to conform to the general usage even if theoretically doleryte is the preferable term. The term anamesyte is but little used at the present time being generally superseded by the variety name of basalt, and it is here inserted simply to show the structural relations.

Diabase would include under it the diabase proper of the Germans, olivine diabase, and much of the diabase-porphyryte, etc. Gabbro is here used to comprise not only gabbro proper but olivine gabbro, noryte, olivine noryte, forrellenstein or troctolyte, kersantyte, most of the teschenyte, etc.

Under the terms dioryte, syenyte granite, phonolyte, gneiss, granulyte, etc., are here included only those forms of basaltic rocks which on account of their alteration are mineralogically or structurally so transformed that they would by lithologists generally be classed under those names. The same can be said of the use here of the term argillyte and schist, as it is intended that under basalt shall come every form or variety which that rock can ever assume, but it is not thought necessary to multiply indefinitely the list of terms which have at various times been employed to indicate all the changes that occur in basaltic rocks — as the changes and corresponding names are exceedingly numerous — more so for the basalts than for any other group. Indeed it may be said that by far the larger number of names in lithology have been at some period of their use applied to some one of the various mineralogical, structural, or alteration forms which basalt assumes.

GABBRO.

Under the variety name gabbro the writer would place all those basaltic rocks which are essentially composed of feldspar (nephelitic or leucite), diallage, or rhombic pyroxene and magnetite or menaccanite, as well as all rocks produced by their alteration.

As a rule they are of a coarser grain or more granitoid in their structure than the diabases, and it is to these granitoid forms that Judd would restrict the name gabbro, and certainly macroscopically it will thus be used generally by lithologists as it always has been. But the more common use amongst micro-

lithologists has been to employ the term to include those basaltic rocks in which the pyroxenic constituent was a foliated form. However, in more recent times those varieties bearing enstatite or hypersthene have been separated into distinct species known as noryte and hypersthenyte. These names, however, seem unnecessary in the light of the relations established between the rhombic and monoclinic pyroxenes, not only between each group but also between the members of each group.

Macroscopically the gabbros are, as a rule, much more granitoid in structure, with the feldspar or pyroxene in larger masses, and of a grayer or darker color than the diabases—which usually show some shade of green. Yet in many cases the two rocks are macroscopically undistinguishable—a fact that has proved to be of more common occurrence in the Minnesota rocks than in those of any other region which I have studied.

The Minnesota gabbros have been studied along two lines, one passing from the coarser crystalline forms towards the finer or more diabasic types, until a group is reached which is closely allied to the diabases, while it is often doubtful amongst which division the individual specimens belong.

The second line of study has been to arrange each group according to the less or greater amount of alteration found amongst its members. This second division has not been strictly carried out but rendered subordinate to the first arrangement. This order of study is not in accordance with that chosen by the writer for his "Lithological Studies," which were intended to detail the results of an extended study of a large series of ancient and modern rocks; but it has been chosen as best adapted to show the relations between the different members of these old Minnesota rocks.

Although the Minnesota gabbros are of a much finer crystalline texture, as a rule, than those studied by the writer from Northern New York, Eastern Massachusetts, San Domingo, and elsewhere, yet in general characters they are otherwise similar.

Macroscopic Characters.

In the Minnesota gabbros, studied by the writer, the least altered forms of the most characteristic type commences with a coarsely crystalline gray rock composed macroscopically essentially of gray feldspar plates, holding interstitial masses of mag-

netite,* biotite, etc. In succeeding forms the feldspar is of a gray to a milk-white color, while macroscopic diallage appears, showing a partial alteration to hornblende, with the distinct cleavage of that mineral. The general structure of the coarsely crystalline gabbros is granitoid, and as they are more altered, the gray tints become darker, passing even to brown or black, although greenish tints sometimes prevail. The Duluth gabbro is especially variable, being in part composed almost wholly of brownish to greenish gray feldspar, often on the fresh fracture closely resembling elæolite. In the more altered portions the feldspar has a grayish white or pinkish color and epidote appears in it. In subordinate quantities there appear in the rock magnetite, amphibole and chalcopyrite. Other specimens of the Duluth gabbro are less coarsely crystalline, while the alteration of the feldspar, with an increasing white or pinkish color, becomes more conspicuous, and yellowish green aggregations of epidote a e common. The alteration to epidote is marked by a central core of that mineral, surrounded by a band of grayish white feldspar; which in its turn is encompassed by a narrow border of reddish or pinkish feldspar. Outside of the last band extends an irregular and indefinite zone of brownish-gray discolored rock. Sometimes the more or less altered, and variously colored feldspars are irregularly intermingled in the different zones, so as to partially or entirely obliterate the banded structure. The so-called Rice point granite is the same gabbro, which has partaken of the grayish-white and reddish alteration of the feldspars, together with the segregation of the epidote, giving to it an appearance closely resembling some coarsely crystalline hornblendic granites, from which resemblance has arisen its common name.

Other specimens of the Duluth gabbro are finer grained, and show macroscopically reddish feldspars, hornblende, epidote, and some quartz. Others again have the magnetite abundantly developed, so much so that the grayish-black rock has been designated an iron ore, which has been mined at Duluth. Some specimens from Duluth show the well-known spheroidal or boulder-like decomposition of basaltic rocks.

In some of the Minnesota gabbros the diallage shows a schil-

* The term magnetite will here be used, for convenience, to designate not only magnetite proper, but also menaccanite, and the intermediate grades of iron ore.

lerization like that common to bronzite, and in certain cases this alteration is carried so far that the mineral easily cleaves into micaceous looking plates, parallel to the basal pinacoid (O. 0P, 001) of the diallage.

The more commonly appearing secondary constitutents of the Minnesota gabbros are hornblende, biotite, quartz, and apatite, and in accordance with their relative abundance is the character of the rock changed. Some forms thus arising through alteration are coarsely crystalline grayish-green compounds of feldspar, hornblende and magnetite, and others are dark or rusty brown, dioritic looking rocks, in which some diallage may or may not be distinguished in the midst of the secondary hornblende. These forms, when the diallage is nearly or entirely wanting, make a more or less normal dioryte and are so named by lithologists and geologists generally. The feldspar in these dioritic rocks is usually of a reddish or grayish color, the same as it often is in the less altered and more normal gabbros.

A further type of altered gabbro is when we have a coarsely crystalline granitoid rock of a pale reddish-brown color, and composed of a flesh-colored feldspar, hornblende, with or without diallage, quartz, apatite, and magnetite giving rise to a rock that might well be macroscopically considered to be a normal granite. Others have as further secondary minerals biotite and calcite. In this connection with the coarsely crystalline altered gabbros are placed a series of altered rocks, which are regarded by the writer as more extreme cases of the same alteration, but whose absolute connection in the majority of occurrences cannot be proved with the material at present at the command of the writer. Amongst these rocks are crystalline gneissoid forms having a banded structure and composed of pinkish and grayish feldspar, and hornblende. Others are dark gray and greenish-black rocks, composed of gray and reddish feldspar, magnetite, and greenish hornblende; with sometimes the addition of quartz, chlorite, and apatite. These rocks are placed with the gabbros, although differing in mineral composition, on account of their resemblance in structure macroscopically and microscopically to the known altered forms of that rock.

Another group of gabbros of somewhat finer crystalline

structure than the preceding are yellowish gray to dark crystalline rocks, macroscopically composed of feldspar and magnetite. In some apatite and pyroxene are seen.

This brings us to the finer grained group of gabbros or those which more closely resemble the diabases proper.

The least altered rocks of this group are grayish and of medium grain. They are composed principally of a clear, glassy feldspar, holding brownish olivine, diallage, and magnetite. As the alteration of these granular rocks progresses, they become dark gray, to grayish or rusty brown, and more or less compact, with the olivine more or less altered to serpentine, and with biotite as an accessory mineral. Most of these rocks are macroscopically undistinguishable from diabase.

Other forms appear to be chiefly or entirely composed of feldspar and olivine, thus forming that variety of gabbro known as forrellenstein.

Microscopic Characters.

In giving the microscopic characters of the Minnesota gabbros the same order will be followed as that taken in giving the macroscopic ones.

The coarser crystalline gabbros are composed of feldspar (principally if not entirely plagioclase), diallage, and magnetite. These rocks, as we successively progress towards the more altered types, show a kaolinization of the feldspar, the production of viridite, a brownish coloration of the diallage and the development of dark plates and needles which often form a rectangular grating structure in it. Biotite and hornblende begin to appear in greater or less abundance, and on further change, quartz, orthoclase, and mica scales are formed in the plagioclase, thus transforming the mineralogical character of the rock.

In some cases the pyroxene is in part altered to biotite, actinolite, and chlorite, and the feldspar to quartz, orthoclase, chlorite, etc., the change in portions of the section being so great that it shows all the characters of a schistose rock, a result purely due to alteration, as the gabbro characters of the remaining portions show. One type of gabbro, as shown in Plate IV, Fig. is composed of fine, rounded grains of diallage inclosed in granular feldspar, the whole presenting a structure

belonging not to a sedimentary but to a rock which has entirely recrystallized after its solidification. All the crystals or masses are composed of rounded forms of a number of rounded grains, usually but little longer than broad. This form applies to the feldspar and magnetite as well as to the diallage. The structure may be congenital but I have seen it only in recrystallized rocks, when any evidence of their history could be obtained. A further change has set in later as shown by the brown biotite on the right hand, and by the green hornblende at the bottom of the figure. This change goes so far that portions of the section form a perfect dioryte, the diallage being entirely altered.

Besides the various forms of foliated schistose or dioritic gabbro, other types exist in which the rock generally, or the groundmass, is altered to a confused mass of viridite, ferrite, quartz, etc., giving to the rock an eozoön or graphic structure, or when the alteration is carried further, the rock becomes changed into one that would be styled by lithologists generally a granite.

Amongst the Minnesota gabbros are several specimens belonging to that variety known as *forellenstein* or *troctolyte*, composed of feldspar with olivine and sometimes a small amount of diallage. The feldspar is largely clear, with broad polarization bands, but sometimes it is cloudy from kaolinization and contains quartz and other alteration products. The olivine in part is unaltered, of a yellowish color and pleochroic, the colors varying from a greenish yellow to a yellowish brown, and a reddish brown. Diallage, in small quantities, is present in some of the sections and contains magnetite dust.

The further special discussions are better taken under the head of the minerals following:

Feldspar.

The feldspar of the Minnesota gabbros is usually in large irregular masses showing broad polarization bands. Optically it appears to belong largely to labradorite and anorthite. In many cases the plagioclase is filled with needles and globulites so commonly seen in the feldspar of gabbros; these are for the most part arranged parallel to the twinning plane, although sometimes oblique to it. Tubular cavities were also observed in lines par-

allel with the same plane. Much of the plagioclase is twinned by the pericline and albite law; and in one case the ordinary twinning could only be seen just at the point of extinction, as the writer found was the case with the plagioclase of the Bishopville meteorite. *

The plagioclastic twinning has largely been obliterated in many cases by the alteration of the feldspar; every condition being observed between that in which the feldspar shows the striations intact to those in which they can be seen in only a few places, and to other specimens in which they are nearly or entirely lost. The obliteration of the striations takes place largely through the kaolinization of the feldspar, and its replacement by ferric oxide, viridite, micaceous minerals, magnetite, orthoclase, quartz, epidote, etc. When the kaolinization is carried to any great extent the triclinic bands are lost in the aggregate polarization produced, and this is true to a greater or less extent when the feldspar is replaced by other minerals.

In some cases when quartz is the replacing mineral the striation and kaolinized patches are preserved intact. This fact was observed in the case of the altered gabbros or diorytes, No. 305, from the outlet to North lake, and No. 334 from Pipestone Rapids. The best occurrence in No. 334 is shown on Plate VIII, Fig. 2. In this the apparently cleaved or striated plagioclase crystal, partially kaolinized and partially clear is seen in polarized light to be composed largely of a homogeneous uniformly polarizing quartz; but part is made up of diversely polarizing quartz grains, the striations extending from one to another.

The reddening of the feldspar, or its common reddish color, is looked upon here as produced largely if not entirely by alteration, † which alteration causes a loss of the striated or plagioclastic character, a fact which has also been observed by Irving.‡

In the study of the rocks of the Northwest some difference of opinion exists concerning the origin of the viridite or chlorite found in the feldspar. My observations indicate that it is generally formed from the feldspar itself and this agrees with the observations of Pumpelly § and Irving, || while Streng ¶ and

* Am. Jour. Sci., 1883 (3), xxvi. 34; Lithological Studies, 1884, p. 200.

† Geology of the Iron and Copper Districts of Lake Superior, 1880, pp. 55, 56

‡ Geol. Wisc. 1880, iii, 171; Copper-bearing Rocks, 1883, pp. 603, 622.

§ Proc. Am. Acad. 1878, xiii. 270, 290.

|| Geol. Wisc. 1880, iii, 189.

¶ Ann. Rep. Minn. 1882, xi, 45, 46.

Julien * look upon it as an infiltration from the adjacent pyroxene. Wichmann † also describes cases in which it is an in infiltration, but in other examples he looks upon the viridite as a product from the alteration of the feldspar.

The replacement of the plagioclase by orthoclase is one of the steps in the alteration of the gabbro rocks; and Irving's orthoclase gabbros do not appear to be a distinct group of rocks but merely an altered condition. This is indicated by Irving's own observations that the orthoclase is more or less clouded, reddened, and charged with secondary quartz; while it always appears as of later crystallization than the plagioclase, conforming to the contours of the latter mineral. The production of the orthoclase gabbros by alteration is further indicated by the fact pointed out by Irving, that their specific gravity ‡ is less than that of the gabbros free from orthoclase. §

Other evidences that these gabbros are simply alteration or metamorphic states of the ordinary gabbro, is the uralitic condition of the pyroxene, the presence of biotite, which is rare in the orthoclase free forms of Irving, the presence of apatite crystals, and the larger amount of titanic acid in the magnetite, with the "leucoxene" alteration.

Diallage.

The diallage is colored black to greenish black. and has a lustre varying from vitreous to resinous. The greenish color appears to be owing to an incipient alteration to hornblende; and when the change has progressed far the mineral becomes of a greenish to brownish black color and has both the fibrous structure and cleavage of amphibole, the rocks thus showing the characters of coarse grained diorytes. Some biotite also appears in connection with the progressing alteration.

Microscopically, diallage is seen to be in irregular masses of a pale yellowish or greenish tint, in the least altered state, but on the commencement of visible alteration it assumes a brownish color, and the usual inclusions of a dark brown to black color are seen. These inclusions appear in the Minnesota gabbros to

* Geol. Wisc. 1880, iii, 228.
† Geol. Wisc. 1880, iii, 603, 622, 623.
‡ Lithological Studies, 1884, pp. 79, 80, 186, 187.
§ Copper-bearing Rocks, 1883, pp. 50, 51.

always arise from the alteration of the diallage and are never primary; while in a large majority of cases they evidently are magnetite or menaccanite,* which has been precipitated during the changing process. Further change in the diallage leads to the macroscopical metalloid appearance known as schillerization; and when this change has been carried still further, a strongly marked micaceous lamination appears in the diallage parallel to the basal pinacoid, which causes the mineral to be often mistaken microscopically for mica.

The relation of the cleavage of diallage to that of augite is a matter of considerable importance, since on this turns all the distinction between the gabbros and diabases, except that part of the former are more coarsely crystalline latter.

Bischof early held that diallage was formed from the alteration of augite.† Roth also holds the same view and claims that there is no essential distinction between the two varieties of pyroxene.‡ Rosenbusch says that a continuous series extends between the typical augite and the typical diallage, and that in general no real distinction exists between these two varieties of pyroxene, gabbro being in substance only an appendix to the diabase rocks.§

Hawes, after studying the New Hampshire rocks, stated: "The unessential nature of the distinction between diallage and augite, and the identification of all the intermediate structural varieties between the most typical specimens of the two minerals, makes more forcible what was previously said in regard to this rock (p. 149), that when strict rules are applied it can only be classified as a variety of diabase."||

Irving uses the term "gabbro and diabase, olivine gabbro, and olivine-diabase, all free from orthoclase" to include the coarse grained basic rocks without distinction as to whether they carry diallage or augite, stating that "the distinction between diallage and augite is a valueless one, since not only are both often found in the same section, but every gradation is found in rocks of this class from augite to diallage." Irving groups the above rocks into one set, while under the coarse

* Rosenbusch, Mikros. Phys. 1885, i, 399.
† Elements of Chemical and Physical Geology, 1855, ii, 333, 334.
‡ Chem. Geol., 1879, i, 10; see also Senft., Die Krys. Fels. 1868, p. 669.
§ Mikros. Phys. 1877, ii, 327-330, 459-474.
|| Min. Lith. N H., 1878, pp. 166, 167.

:ained rocks are also placed in distinct groups, orthoclase-bear-ng gabbro; hornblende-gabbro, and anorthite rock.*

A further proof of the close relationship of augite is the case cited by Rutley, of specimens presented by him for examination, both to Rosenbusch and Renard, who found themselves unable to agree, one considering the mineral to be augite, and the other holding that it was diallage.†

Julian likewise holds that diallage results from the alteration of augite.‡

The same view was taken by Pumpelly at the same time.§

Judd has recently given quite a full discussion of the subject, stating that "both the green augites (diopside) and the black varieties (common augite) of the Western Isles of Scotland are found, when traced into the more deeply seated masses, to pass gradually into the 'Schiller' varieties, known as diallage and pseudo-hypersthene. That this is the result of a secondary modification, is proved by the fact that the alteration of the crystals is seen in many cases to be confined to their outer portions, so that a nucleus of ordinary augite is surrounded by a shell of diallage; in other cases the alteration of the augite into diallage is seen to take place along cracks, due to cleavage or other causes, which intersect the crystal; in other cases, again, the alteration into diallage is found to occur in irregular patches within the augite, though the cause of the distribution of these altered patches may not be manifest from a study of the thin section. Although the alteration of the augite may be set up along the cleavage-cracks of the crystals, yet the position of the brown inclosures bears no relation to the principal (prismatic) planes of cleavage in the mineral. On the contrary, the inclosures appear to be developed in planes parallel to the orthopinacoid planes, in which only a very imperfect cleavage exists in augite. In the island of Rum, the augite, though exhibiting the first traces of the development of the structure, which is characteristic of diallage, is seldom so far altered as to deserve being called by that name In the larger igneous masses of Mull, the augite in all the central portions is in the condition of diallage, as was pointed out

* Copper-bearing Rocks, 1883, pp. 36, 37.

† The Eruptive Rocks of Brent Tor, 1878, pp. 38, 40.

‡ Geol. Wisc., 1880, iii, 236.

§ Ibid p. 42.

by Zirkel. Between rocks in which the augite is entirely unaltered, and those in which it is completely transformed into diallage, every possible transition may be found." *

That the cleavage of diallage is congenital seems to the writer to be true for some cases, since he has observed it well developed in the diallage of meteorites which showed no evidence of alteration.†

But his investigations on the diallage bearing peridotytes convinced him that no real difference existed between augite and diallage but that the two formed a continuous series.‡

Besides the normal diallage with its original cleavage, there occurs another form in the Minnesota gabbros whose cleavage arises solely from alteration of distinct and well-marked augites, thus confirming the view of those observers who have held that diallage is an alteration form of augite, i. e., this is true for diallage in part of its occurrences, but not for all.

Fig. 1, Plate VII, illustrates the relation of the augite cleavage to the secondary cleavage of the diallage. The augite cleavage runs lengthwise of the crystal or vertically in the figure, while the secondary diallage cleavage extends from left to right and right to left, extending inwards from the exterior, leaving patches of the unaltered augite included. The alteration to diallage is accompanied by an entire obliteration of the augitic or longitudinal cleavage. The diallage itself passes into a viriditic substance, which in its turn has passed into a brown hornblende—the alteration being seen to increase in completeness as it is studied from the centre outwards, as it began on the edges first. Although the cleavage of the diallage and the fibrous structure of the viridite are arranged at right angles to the cleavage of the augite, the hornblende cleavage is parallel with that of the augite. Neither the diallage nor the hornblende correspond in orientation with the augite, yet the hornblende in the detached patches on both sides of the augite shows optically that it is the same crystal; thus indicating that had the alteration progressed to completeness there would have resulted a homogeneous brown hornblende individual.

Fig. 2, Plate VI, shows the development of the diallage cleavage to such an extent as to produce schillerization, or a fib-

* Quart. Jour. Geol. Soc., 1885, pp. 378, 379.

† Lithological Studies, 1884, pp. 94-101; 167.

‡ Ibid, p. 169.

rous structure with clear intact patches. This diallage is evidently a secondary concretionary product in the rock, which mineral shows subsequent alteration.

Plate VII, Fig. 2, shows a core of diallage surrounded by a greenish viridite which penetrates along the fissures. The viridite on its exterior passes into a yellowish-green hornblende.

Plate VIII, Fig. 1, represents a diallage core which is much altered and surrounded by a green hornblende arising from the alteration of the diallage. Scales of this hornblende are abundant in the diallage core. This hornblende passes on the outer edge into a brown hornblende with the well-marked prismatic amphibole cleavage; it also passes into a reddish-brown biotite associated with magnetite and yellowish epidote.

Plate I, Fig. 2, shows at the upper left hand a diallage crystal partially altered and filled with secondary magnetite. The portion of diallage above that shown in the figure is relatively clear and unaltered. but below the portion containing magnetite, it passes into chlorite, and the rock here has a radiated fibrous structure and possesses the characters of a chlorite schist bearing magnetite.

Plate IV, Fig. 2, illustrates the formation of brown biotite in diallage from the alteration of the diallage itself. This biotite is formed approximately along the fissure and cleavage planes of the diallage.

Judd apparently looks upon schillerization as dependent upon and due to the depth of the rock during its solidification,* but this hardly seems correct for the cases observed in the Minnesota gabbros.

The fine Striations described by Williams,† traversing irregularly crystals of diallage, are doubtless produced the same as those observed on the biotite in some of the Minnesota sections, i. e. by the pressure and grooving produced by the corundum used in grinding the section, which changed the molecular condition along the ground lines.

Amongst the alteration products of diallage observed by the writer in the Minnesota gabbros are viridite, chlorite, biotite, matted masses of actinolite and biotite, green and brown hornblende, magnetite, both in dust and needles, etc.

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* Quart. Jour. Geol. Soc., 1885, pp. 386-389.

† Bull. U. S. Geol. Sur., 1886, p. 22.

Similar alterations have been observed in the rocks of the Northwest by Streng, Pumpelly, Irving, Wichmann, Wright, and Julian. From the alteration of the diallage gabbros pass from the normal form into chlorite schists, diorytes, and with alteration of other minerals in the rocks, into syenytes and hornblende and biotite granites, gneisses, etc.

Enstatite.

Enstatite is not an abundant mineral in the Minnesota gabbros studied by the writer, and its characters are best given by reference to special cases. In the rock, No. 787, found on the south slope of the Mesabi range the enstatite is of a brownish color indicating the commencement of alteration, and which is further shown by the development in it of fine smoky ferruginous bands which are paralled to the principal cleavage. The enstatite, as shown in Plate III, Fig. 1, is built out upon the olivine or forms a ring surrounding that mineral. Yet the enstatite but rarely corresponds with the olivine in optical orientation.

In the rock coming on the south shore of Little Lake, No. 692, the large irregular masses of diallage inclose rounded and irregular patches of enstatite, as shown in Fig. 2, Plate II. This enstatite is cloudy from the secondary magnetite dust and needles developed in it.

The rock from the second island east of Beaver bay, No. 133, has as its pyroxenic constituent a clear pale brown enstatite, which is much fissured and, except optically, is identical with common augite. It is in irregular masses cut by the feldspar crystals. On its edges and the borders of the fissure it shows the fine parallel secondary cleavage of enstatite which is identical with the secondary diallage cleavage occuring so commonly in the pyroxene of the Minnesota gabbros (see Plate II, Fig. 1.)

The enstatite in a rock from Silver islet, No. 595, closely approaches Judd's proto-bronzite. This enstatite is altered both to a dull dark green bastite, and to biotite.

Although a few of the Minnesota gabbros have as their pyroxenic constituent enstatite alone, while others contain enstatite in association with diallage, it has not seemed best to employ the term noryite, which is now generally used for the enstatite-bearing gabbros. The reason is that the enstatite does not make

any essential difference in the rock, thus rendering the distinction of noryte from gabbro a purely microscopical one, and introduces a term which only renders lithology just so much more of a stumbling block to geologists than she now is. Judd's observations, indeed, make it evident that in the field there is no distinction between the norytes and gabbros, but that they are one and the same rock. Of course the petrographer, who bases his divisions on a mineralogical system, must, for consistency, use the term noryte, since the mineralogical composition of the rock has changed, although the rock itself has not. The writer may be charged also with inconsistency in thus rejecting the term noryte, when in the peridotytes he has not only adopted names based on the mineralogical characters alone, but even prot posed some. The reason for using those names, as explained in the "Lithological Studies," was to render the work as consonant as possible with that of other petrographers, and so the variety names were used, although looked upon as non-essential. Further, the nomenclature of the peridotytes was microscopical, as it had sprung up mainly since the use of the microscope in lithology, and had passed into general use, while nomenclature of the basaltic rocks is largely of older origin, and originally based chiefly on physical characters, however much the mineralogical element may have been supposed to enter into the names. Hence it would seem unnecessary to inflict upon the geologist any greater multiplicity of names than absolutely necessary, of forms having no macroscopic distinction, in a group rocks in which the nomenclature is already so burdensome as it is in the basalts.

Olivine.

The olivine in the Minnesota gabbros is clear or yellowish green in the unaltered condition, but is largely altered to a dark reddish, brownish, or yellowish serpentine, and to dark brown to black ferruginous products. The common mode of alteration of the olivine has been often described. Its serpentinezation usually begins along the border of the fissures of the olivine grain and on its periphery, forming on each edge a narrow band of serpentine (chrysotile) with the fibres standing at right angles to the edge. As a further stage in the alteration there is formed inside of the chrysotile bands an interior band of clear serpentine, containing

the remains of the unchanged olivine, which in its turn passses into serpentine. Olivine crystals can usually be found in every stage of this alteration, while in many cases only one or two steps in the process are visible, the fissure lines and the last altering interior portions being only distinguishable by contrast in structure. Frequently magnetite is precipitated in black bands or gains marking principally the fissure structure, but during the later process of alteration the magnetite is often dissolved. In the extreme alterations all traces of the mode of formatation of the serpentine disappear, and the olivine pseudo morph becomes a homogenious serpentine or else the olivine is replaced by quartz, calcite, limonite, ferrite, opacite, hematite, magnetite, etc., according to the conditions under which the alteration and replacement has proceeded.

In one case a very peculiar form of alteration of olivine to serpentine was observed. In the earlier stages black and brown plates and needles have separated out. These for the most part are arranged parallel to the macrodiagonal, although a few are at right angles to it. The olivine further shows two well marked cleavages corresponding to the macro- and brachy-diagonals or to the arrangement of the schillerization plates, and the alteration is greatest as a rule on the brachy-diagonal lines. Thus in the more highly altered olivines is presented an elongated crystal crossed by alternating bands of serpentine and olivine. In some cases the alteration bands are parallel to the macrodiagonal, while in others the entire crystal is altered to fine parallel serpentine bands. See Plate VII, Fig. 2.

The olivine in some of the forrellensteins of Minnesota shows a well marked pleochroism, the colors varying from greenish yellow to yellowish brown, and reddish brown.

In the coarser or more granitoid gabbros no unchanged olivine has been seen in the Minnesota rocks by the writer, and the distinguishable alteration forms in only a few cases, except in the forrellensteins, but in the finer grained gabbros olivine and its pseudomorphs are very common.

Fig. 1, Plate V, shows the structure of the nearly unaltered olivine in the forrellenstein traversed by fissures and a few bands of greenish serpentine. Fig. 2 of the same section shows the olivine altered to a reddish brown and yellowish serpentine excepting numerous grains lying in the plexus of serpentine formed along the fissures and contours of the olivine.

Fig. 1. Plate III, incidentally shows the form of olivine and its partial alteration in a Minnesota gabbro (olivine noryte).

Judd opposes the division of the gabbros into "olivine gabbros" and into "olivine free gabbros" and the present writer would agree with him, for it is contrary to every principle of true science to define anything by *what it is not*, as the terms "olivine free," "feldspar free," "quartz free" do. No term is proper in any science unless it designates the thing that it is and not the thing it is not; further, such terms are exceedingly awkward and do violence to the construction of the English language, however proper they may be in the German. Judd states: "I have shown that in most cases where olivine is thought to be absent from these rocks it has really been altered into magnetite or serpentine. I believe that all the gabbros in their unaltered condition contained olivine, though in very varying proportions; and that in the few cases where we find a rock of this class in which olivine is not represented as an original constituent it should be classed with the eucrytes."*

The writer's experience agrees in a great measure with that of professor Judd, as in the Minnesota gabbros, in the more highly altered and more coarsely crystalline forms, but little olivine can be found, even recognizable by its pseudomorphs. This is what would naturally be expected since the olivine would be most readily obliterated in the coarsely crystalline rocks and would have less distinctive contours whereby its pseudomorphs might be distinguished. In the majority of the finer grained gabbros olivine or its marked alteration forms are commonly seen until the rock alteration has proceeded to an extreme degree. However, the absence of olivine in the gabbros I would not in all cases attribute to alteration, but to the local variations in the basaltic rocks the same as the writer pointed out in 1879, indicating that olivine may not be present in a rock which is a genuine tertiary basalt, and from which the olivine could not have been removed by alteration as the rock was unaltered. The explanation of this variation in the presence of olivine naturally follows from the claim put forth in that paper, and mentioned in this article, that olivine in almost every case, if not in every one, was not the direct product of crystallization from the basaltic magma, but was a foreign mineral which had been more or less

* Quart. Jour. Geol. Soc., 1886, p. 62.

dissolved by the corrosive action of the heated magma. This solution of the olivine material, when perfect, removed every trace of olivine from the rock, and every gradation was traced by the writer between that state and those in which the olivine was exceedingly abundant. The evidence in behalf of this view was in part the rounded, gnawed, fractured, and penetrated forms of the olivine grains, their being blackened on the edges and rendered magnetic, by tracing the various stages until there was found to be only a few remains of ferrite or opacite grains to indicate the disappeared olivine, and lastly by the fact that the augite was in an inverse proportion to the olivine, and was so associated with it as to render it probable that the augite resulted from the crystallization of a portion of the olivine material united with the magma.*

A still further reason for believing that olivine is not always a constituent of terrestrial gabbros is the fact that it is not always present in the meteoric gabbros from which by no possibility could it have been removed by alteration.†

I have discarded the name of *olivine gabbro and olivine free gabbro*, not so much from the fact that in many, if not in most gabbros, the olivine free state is brought about by the replacement of the olivine by secondary products; but because the presence or absence of the olivine makes no essential difference in the charter of the rock, and the distinction is a trivial one, unless the lithologist is working from a purely mineralogical standpoint.

Magnetite.

The magnetite often presents the velvet black color with the brilliant sub-metallic lustre characteristic of most menaccanites and some magnetites, and closely approaching that of chromite.‡

In local modifications of gabbro, the magnetite predominates to such an extent over the other minerals that it is mined as an iron ore. The quantity of this ore is very great, and a number of mines exist upon it at various localities—the only apparent limit to its being extensively mined is owing to the titaniferous nature of the ore. Attention was called to the

* On the Classification of Rocks, Bull. Mus. Comp. Zool., 1879, v, 278, 279.
† Lithological Studies, 1884, pp. 196-206.
‡ Lithological Studies, 1884, pp. 178, 180.

eruptive nature of these iron deposits by Prof. N. H. Winchell, in the annual report for 1881, page 80: and later by Irving, in 1883, in the "Copper-bearing Rocks," page 51. Since this ore is simply a local modification of the eruptive gabbro, we have here at least an occurrence of eruptive iron ore, even if it has been strenuously denied that any iron ores of such an origin exists on the globe.

The term magnetite is employed generally in this work for the iron ore, whether it is pure magnetite or titaniferous bearing magnetite or menaccanite. These ores generally seem to be titaniferous magnetite,* the titanium varying from a minute amount up to 12 per cent or higher. Hexagonal crystals of menaccanite were seen by the writer, although they were evidently of secondary origin in the rock, while he has observed considerable leucoxene in connection with the iron ore, particularly in the diabases. In some cases the iron ore forms black rectangular or oblique gratings in the leucoxene, having angles of 90°, 71° and 109° approximately. Magnetite is commonly produced during the alteration of olivine, diallage, enstatite, and augite; and also from any of the iron-bearing minerals, when acted upon by the molten magma. The magnetite secreted during the alteration of the minerals is later absorbed or united with other mineral matter, or else becomes aggregated into heaps of grains or into a crystalline grain or mass. Magnetite in partially altered rocks is often surrounded by ferruginous material, or by clear fibrous polarizing substance, or more commonly by a deep reddish brown biotite. This biotite is evidently formed from the magnetite with associated feldspathic material during the process of the alteration. More rarely the mineral associated with the magnetite, out of which the biotite is formed, is pyroxene.

Attention was early called by Hawes to this association of biotite and magnetite, and one case was figured by him in his mineralogy and lithology of New Hampshire, 1878, page 205 and Fig. 6, Plate XI. He stated that "almost every one of the larger grains of the titanic or magnetic iron is surrounded by foliæ of biotite radially arranged in fan shapes, with the iron oxide as a nucleus. * * * It is possible that the mica scales grouped themselves about the grain while the rock was plastic, or that they were formed there by a reaction between the sili-

* Ann. Report Minn., 1881, x., 81; Copper-bearing Rocks, 1883, pp. 41, 42, 51, 52.

cates and the iron oxide. This is no isolated occurrence. In our gabbro the biotite and iron oxide are almost always associated, and I think that the mica was formed by a reaction in which the iron oxide took part, and therefore the minerals are thus associated."

Attention was later called to the association of biotite with magnetite by Pumpelly* and Irving,† although neither offer any explanation of its origin.

In 1884 the writer gave figures showing this association of secondary biotite with magnetite in the Cumberlandyte or iron ore of Taberg, Sweden, and like formation of biotite in the Cumberlandyte from Rhode Island, was also pointed out.‡

Sometimes the magnetite is seen to offer a base, or nucleus, about which the pyroxene has crystallized as a centre. Occasionally in the altered rocks it is seen to be surrounded by pyrite, which also interpenetrates the fissures of the magnetite.

Fig. 2, Plate I, shows the formation of secondary magnetite in pyroxene and in chlorite schist. Plate III, Figs. 1 and 2 show the secondary biotite formed in connection with magnetite, while the same thing is shown on a larger scale in Plate VI, Fig. 1. Figs. 1 and 2, Plate X, show the formation of magnetite through the partial destruction of foreign hornblendes in andesite by the molten magma.

Biotite.

Biotite, so far as observed, is always a secondary or alteration product in the Minnesota gabbros. Its usual colors are green, yellowish brown or deep reddish brown, according to its stage of alteration and the conditions under which it has been formed, the darker color existing particularly when well formed in association with magnetite. It exists in the gabbros in plates, scales, fibres, and in crystals showing cleavage and marked pleochroism.

Secondary biotite often exists, forming a fibrous border or well defined scales or crystals about magnetite, to which attention has been more fully called under that mineral.

Biotite is produced during the alteration of the rhombic and

* Geol. Wisc. 1880, iii, 38.
† Copper-bearing Rocks, 1883, p. 51.
‡ Lithological Studies, 1884, pp. 77, 81; Plate II, Figs. 2 and 3.

monoclinic pyroxenes, feldspar, olivine, and hornblende, and is a common alteration product in the Minnesota gabbros.

Some of the sections show in the biotite an irregular cross banding, cutting the cleavage planes at a slight angle. It is indistinct in common light. The same indistinctness exists if the section is studied when placed right side up over the polarizer, but if the section is reversed, the banding is very distinct both in common light and when placed over the polarizer.

Between crossed nicols the banding is clearly defined whether the section is placed right side up or reversed, but in the first case it is when placed parallel to the plane of vibration of the lower nicol, and in the second case when at right angles to it. This striation structure is attributed to the action of the corundum used in grinding the section, which has grooved the biotite and altered the molecular tension along the grooved lines. This furrowing is upon the back or underside of the section. To the same grooving by corundum is attributed the banding of diallage described by Williams, which is referred to under the head of that mineral (ante ——, page 00).

Plate III, Fig. 2, shows the formation of biotite from the alteration of pyroxene. Fig. 1, of Plate IV, shows, on the lower right hand, a secondary biotite formed by the alteration of the pyroxene grains in the section. Fig. 2 of the same plate shows the formation of biotite along the fissures and cleavage planes of diallage. The formation of secondary biotite in connection with secondary hornblende is shown in Fig. 1, Plate VIII.

Biotite was also observed in the feldspar of the Minnesota rocks forming thin plates and needles arranged parallel to the twinning and other crystallographic planes. The mode of occurrence is much like that seen in aventurine feldspar.

Hornblende.

All the hornblende seen in the gabbros of the Northwest is believed by the author to be secondary, as he has generally claimed it to be in the majority of cases in the basic rocks which he has studied since he commenced his petrographical work. In color, it varies from a light or yellowish green to a dark brown or yellowish brown — the darker stages being simply the more perfected condition of the greener or uralitic stage.

The production of the hornblende from pyroxene has been

figured in a number of plates in this work and attention called to the occurences under the head of diallage, to which the reader is referred.

Quartz.

This mineral is very abundant in many of the gabbro rocks of Minnesota, but always of a secondary origin, arising chiefly from the alteration of the groundmass and feldspar, and less frequently from the pyroxene. In the earlier stages of alteration of the groundmass or feldspar there arises a confused mass of viridite, ferrite, magnetite, quartz grains, feldspathic material, etc. As this alteration progresses the tendency is to assume a radiated fibrous structure or else an imperfect graphic form. Further changes in the rock results in the quartz taking upon itself a true graphic form, the same as that seen in graphic granite, while in still further changes the quartz is in rounded or irregular forms in the midst of the altered reddish-brown feldspathic material. The pyroxenic element in the meanwhile has been altered to biotite and hornblende; and in different specimens, according to the grade and character of the alteration of the rock, there are produced rocks that are variously styled by lithologists, quartz-dioryte, augite-quartz-dioryte, syenyte, augite-syenyte, biotite or hornblende granite, etc.

The same alteration has taken place in rocks of a more acidic character. Attention was first called to this alteration in the Lake Superior rocks by the present writer* and the same structure has been described and figured by Irving.† These detached graphic grains of quartz often polarize as one individual, which individual, in the cases seen by me, is not confined to a single altered feldspar crystal as stated by Irving (l. c. p. 113).

From the observations made by myself there appears to be but little doubt that all of Irving's augite syenytes are simply altered forms of basaltic rocks, which have been formed by the process of alteration above referred to, and probably some of his supposed more acidic rocks fall in the same list.

Fluid cavities with moving bubbles as well as microlites are seen in the secondary quartz of these altered gabbros. In like

* Geology of the Iron and Copper Districts of Lake Superior, 1880, pp. 113-122; Lithological Studies, 1884, p. 173.

† Copper-bearing Rocks, 1883, pp. 94-124.

manner these fluid cavities with moving bubbles are abundant in the veinstone quartz described under the andesitic porodytes, showing that the fluid cavities are plainly of secondary origin in the rocks.*

The secondary origin of trichites, magnetite, biotite, etc., in quartz is likewise shown by their occurence in this alteration quartz. The inclusions, especially fluidal ones, are generally arranged along mended fissure lines in much of the original quartz. Besides the quartz described above of secondary orgin, I have collected evidence for a number of years showing that part of the corroded and fissured quartz, penetrated by the groundmass in quartz porphyry, is not foreign, as I formerly supposed it to be, but that it has been formed in the rock as an alteration product subsequent to the solidification of the rock, and is due to the migration and aggregation of the silica set free during the alteration of the rock and its groundmass—the groundmass being included during the crystalization of the silica, or, when the process was not complete, left as interpenetrating tongues.

This statement of course does not apply to the quartz of modern rhyolytes, or to the majority of that found in the old forms of rhyolyte.

The secondary quartz formed in the Minnesota gabbros is shown about the hornblende in Fig. 2, Plate VII, while the graphic and granitoid structure are given in the two figures of Plate IX. The replacement of feldspar by quartz with the retention of the plagioclastic striation is shown in Fig. 2, Plate VIII.

Apatite.

This mineral is found in microlites and long needle-like crystals. It is however observed chiefly in the altered coarser or granitoid gabbros, and is to be found in the secondary quartz, hornblende, and feldspar as well as penetrating the altered groundmass and partially altered feldspar. This mode of occurence, with the increasing abundance in proportion to the alteration of the rock, and its being found in known secondary minerals like quartz, indicates that in the majority of its occurences, if

* Vogelsang, Philosophie der Geologie, p. 155; Julian, Am. Quart. Microscopical Jour. 1879, i, 103-115; Wadsworth, Geology of the Iron and Copper Districts of Lake Superior, 1880, pp. 51, 54; Lithological Studies, 1884, p. 46.

not in all, it is a product of alteration in the rock and due to the aggregation of the phosphate of lime in the rock during the general process of the rock alteration.

Minor Minerals.

Chlorite is a common product in the alteration of the Minnesota rocks, particularly of the more compact forms. By its production the rocks pass into forms known as chlorite schists (Fig. 2, Plate I.) It occurs mainly in pale greenish scales from the alteration of groundmass, feldspar, and pyroxence. Viridite is a term employed by many lithologists to indicate the indeterminable greenish product of alteration of rocks—base, groundmass, feldspar, and pyroxene. It simply marks a stage in the alteration process, and when the alteration is further completed the viridite crystallizes as chlorite, biotite. hornblende, etc., as the case may be. The so-called chlorite itself is often only a stage in the process of mineral alteration, which in the end results in some other mineral.

Epidote in rocks is always a secondary product, largely from the feldspar, but also from the alteration of pyroxene and hornblende minerals. It is commonly associated with secondary quartz, chlorite, biotite, or hornblende.

Tourmaline is of a rare occurrence in the Minnesota rocks studied here, but has been found in radiated crystals of yellowish or bluish color.

Calcite, as a secondary product, occurs in some of the altered granitoid gabbros; it contains in its midst crystals of secondary quartz.

Muscovite, or some of its hydrous forms, occurs commonly in the Minnesota rocks as a secondary product formed during the alteration of the feldspar.

Titanite and pyrite are common as secondary products in the altered rocks, both in some part being formed by alteration of the magnetite, as well as by the alteration of other minerals.

SPECIAL DESCRIPTIONS.

696. *North shore of Mayhew lake, S. E. ¼, Sec. 36, T. 65, R. 3 W.*

A coarsely crystalline gray rock, composed chiefly of plates of

gray feldspar holding feebly, magnetic iron ore, biotite, etc. Under the microscope it is seen to be composed principally of plagioclase, diallage, and titaniferous magnetite. A little unstriated feldspar was observed. The diallage is of a brownish color and somewhat altered, in places passing into viridite. A very little biotite of secondary origin was seen in association with the diallage and magnetite. The feldspar is somewhat altered to the common grayish-white white product of its change (kaolin?) but still retains its plagioclastic character strongly marked by its broad polarization bands.

133. *Second island east of Beaver bay.*

The section is granitoid in structure and composed of plagioclase, enstatite, magnetite, yellowish-brown olivine pseudomorphs, and viridite. The enstatite is of a clear pale brown color. It is much fissured and in common light identical with augite. It is in irregular masses which in most cases show on the edges and sometimes through the entire mass, the fine parallel secondary cleavage of enstatite, which here is identical with that of diallage. This cleavage in every enstatite grain lies parallel to that of every other grain in the section, or at least so near that any difference was not observed. Further, every enstatite mass in the section extinguishes at the same point, i. e., when the secondary cleavage is parallel to the plane of vibration. The feldspar in the main is clear but in places contains much viridite, part of which shows a sphyrulitic structure.

Fig. 1, Plate II shows the general character of the augitic-looking enstatite. It is clear in the main portion but traversed by fissures, along which is shown a fine parallel fibrous or cleavage structure arising from alteration. The feldspar shown in the upper portion of the figure cuts the enstatite which is of a later crystallization.

706. *Mayhew lake.*

Has the gabbro in contact with a fine reddish graitoid rock and is a type similar similar to No. 696, but is more altered.

702. *Mayhew lake.*

Is a coarsely crystalline rock, with its diallage much altered, and having in places the cleavage of hornblende. The plagio-

clase shows a gray to a milky white color. In the section the diallage is seen to be much altered, showing a grating structure. This structure does not seem to be due to the appearance in the mineral of sècondary ferruginous products but rather to an abnormal development of the cleavage planes—particularly along the line of principal cleavage. The diallage is altered partly to greenish and partly to brownish hornblende. The feldspar is considerably altered and kaolinized. It contains secondary chlorite.

773. *Frog Rock river.*

A coarsely crystalline dark or brownish gray granitoid rock somewhat resembling No. 696.

Its pyroxine constituent is seen under the microscope to be altered to viridite and a greenish and brownish biotite. The plagioclase is somewhat changed and contains secondary orthoclase, quartz, mica scales, etc.

In one portion a pyroxene, in a triangular mass, is seen remaining as pyroxene in one part and altered to a greenish brown biotite carrying magnetite in another portion of the same mass.

A radiated group of epidote crystals was observed in the section.

Plate IV, Fig. 2, shows the relation of the biotite formed from the alteration of the diallage. It extends along the cleavage and fissure lines with portions of the unchanged pyroxene between. The whole is surrounded by somewhat kaolinized feldspars bearing biotite.

713. *North shore of Tucker lake.*

Is a coarsely crystalline rock, darker gray but much like No. 773. As seen under the microscope, its pyroxenic constituent is diallage and some probable augite. The pyroxene is in part altered to biotite, actinolite, and chlorite. The feldspar is also much changed and replaced by secondary minerals such as quartz, orthoclase, chlorite, etc. Some portions of the section possess the characters of a schistose rock as the result of its alteration. This is shown in Plate 1, Fig. 2. In the upper left hand portion a pyroxene crystal is figured, showing the precipitation of magnetite as part of the alteration process. The diallage also contains chloritic material and passes at the lower end into a

chloritic mass, while around this lower portion is a beard of magnetite arranged as it would be on the pole of a bar magnet. The upper portion of the diallage, not shown in the figure, is but little altered. The section below is composed of quartz and radiating fibres of chlorite, all bearing magnetite of secondary origin, giving to the rock the characters of a chlorite schist.

699. *North shore of Mayhew lake.*

Is also a coarsely crystalline granitoid rock in which brownish and whitish feldspar plates predominate. Under the microscope, part of the diallage is seen to have been changed to green hornblende, while a border of secondary biotite was observed to extend along some of the diallage crystals.

769. *Northwest end of Little Saganaga.*

Is a brownish gray coarsely crystalline rock like the preceeding. In the thin section the rock is seen to be somewhat altered while it has its plagioclase filled with the brownish needles and globulites so commonly seen in the feldspars of gabbros. These, as usual, are arranged along cleavage planes, one well marked arrangement being parallel to the polysynthetic twinning planes, although one crystal was observed in which no microlites were seen, whose position corresponded to the striation lines, but all cut these lines at a small angle.

701. *North shore of Mayhew lake.*

Is a greenish gray rock, more altered than the preceeding (No. 769) and contains biotite and hornblende, or at least a green and black mineral with the amphibole cleavage. In the thin section the pyroxene appears to have been principally altered to a fine matted mass of actinolite fibres and to biotite; but the plagioclase has suffered less change than would naturally be supposed from the amount of alteration in the pyroxene. Considerable biotite of a secondary origin is to be seen fringing the magnetite grains. The usual needles and inclusions common in the feldspar of gabbros occur here in a manner that indicates that they are the result of the commencement of the plagioclastic alteration rather than original forms.

1. *Duluth.* (*N. W.* ¼, *Sec.* 34.)

A coarsely crystalline variable rock. Part is colored brownish gray to a greenish gray owing to the color of the feldspar, which mineral comprises nearly all of the rock. This feldspar has in places on its fresh fracture a color and lustre closely like that of elæolite. In places the feldspar is so changed as to present a grayish white or pinkish color, and is associated with secondary epidote. The rock also contains, in subordinate quantities, magnetite, amphibole, and chalcopyrite. Other specimens are less coarsely crystalline and the white and pinkish alteration of the feldspar becomes more strongly marked, while the yellowish green epidote forms conspicuous segregations. This alteration shows a central mass of epidote, then a band of grayish white feldspar surrounded by a narrow border of reddish or pinkish feldspar. Outside of this an indefinite irregular brownish gray discoloration of the rock extends. Sometimes the different colored feld-spars are irregularly intermingled.

1 A is the same rock but was taken from a point further to the northeast. In this, nearly the entire rock has partaken in the grayish white and reddish alteration of the feldspar, with the segregation of epidote, thus giving to the rock an appearance closely resembling some coarsely crystalline hornblendic granites, hence the common name of "Rice Point granite."

1 C belongs to No. 1, but is finer grained, has a higher specific gravity, and contains abundant magnetite. Its color is grayish black and is a portion of the gabbro mined for its iron ore at the Duluth iron mine.

1 D is a more highly altered condition of No. 1, and occurs in masses showing the well-known boulder or spheroidal decomposition. It is of a reddish and grayish white color, owing to the color of the altered feldspar, and contains much epidote and some quartz as secondary products.

1 E is a nodule of brownish gray feldspar crystals containing epidote.

Under the microscope the thin sections possess the following characters: The sections of No. 1 are mostly feldspar, which, tested by the Levy-Pumpelly method,* gives angles of 13° to 14° and therefore would be classed as labradorite. It contains nu-

* Lithological Studies, 1884 pp. 40-41.

merous tubular cavities arranged parallel to the twinning planes, also many glass and other inclusions. The feldspar is somewhat altered and cloudy, some of the sections having suffered greatly.

Included in the feldspar is magnetite, chlorite, viridite, uralite, quartz, and diallage closely approaching augite. The diallage is in places altered to uralite, etc.

A few globular aggregately polarizing green masses, containing more or less magnetite, appear to be pseudomorphs after olivine grains. In one section the diallage has been entirely altered to a green fibrous amphibole.

1 A has its feldspar but little altered; this shows, by the Levy-Pumpelly method, angles of 18° to 20°, and therefore probably labradorite. It is twinned partially by the albite and pericline law. The diallage is somewhat altered but shows plainly the diallage structure. In places it has been altered to a mass of pale greenish and colorless fibres of actinolite. A similar alteration of diallage has been observed by Pumpelly.*

1 E is composed chiefly of large, lath-shaped plagioclase crystals more or less kaolinized, and inclosing magnetite, epidote, quartz, and the greenish alteration products of diallage.

Analysis was made by Prof. J. A. Dodge, of the feldspar of No. 1, with the following result:

SiO_2	49.78
Al_2O_3, Fe_2O_3	32.36
CaO	11.55
MgO	1.32
K_2O	0.41
Na_2O	3.30
H_2O	1.83
	100.76

Of this analysis Prof. Dodge states:

"The feldspathic portion was selected (by mechanical means) as clean as possible," but it was not wholly unmixed with the other constituents of the rock.†

This analysis, as well as the optical characters, indicate that the feldspar is labradorite.

A complete analysis was also made of the rock as a whole by professor Dodge, with the following result:

*Geol. of Wisc., 1880, iii, 39,182.

†Ann. Report Minn., 1881, 1881, x. 204.

No. 1. Sp. Gr. 2.79, 2,802.

SiO_2	50.43
Al_2O_3	23.83
Te_2O_3	17.63
TiO_2	trace
CaO	4.79
MgO	2.46
K_2O	0.22
Na_2O	1.66
	98.63

689. *Cross lake.*

Is a gray crystalline rock with its feldspar turned chiefly to a gray or pink color. Under the microscope the feldspar is seen to be in lath-shaped crystals with triangular interspaces containing magnetite, viridite, etc. The feldspar is much altered and filled with kaolin and micaceous scales; but in places it is clear, showing the polysynthetic twinning of plagioclase. Some secondary quartz and feldspar occur, and the pyroxenic constituent is replaced by viridite.

721. *Between Gunflint and Loon lakes.*

A dark green section, composed of partially altered augite, diallage, feldspar, magnetite, and secondary quartz, biotite, hornblende, viridite, and apatite. The section is stained in places yellowish from ferric oxide. The pyroxene is altered along its edges and even often throughout its interior to viridite, biotite, and hornblende (both green and brown). The alteration extends generally along the cleavage planes, which in the diallage appear to be produced from a change in the common augite. The feldspar is kaolinized and contains quartz and other secondary minerals. The rock, mineralogically, could well be pronounced a hornblende-biotite-granite bearing accessory pyroxene, although it is evidently an altered basalt of the gabbro or diabase type.

772. *East and West lake.*

Is a very coarsely crystalline rock, macroscopically composed of feldspar, hornblende, biotite, quartz, and magnetite. The section shows a partially altered plagioclase, biotite, quartz, viridite, and magnetite. Of these the quartz, biotite, and viri-

dite are secondary or alteration products. Another section shows some diallage, with green and brown hornblende and biotite as associated alteration products of the diallage. The section contains secondary quartz and titanite, and much of the rock is a typical quartz-dioryte formed by the alteration of a gabbro.

670. *One fourth mile south of Lake Abita.*

It is a rusty brown coarsely crystalline rock, discolored by surface weathering. Composed, macroscopically, chiefly of brownish ferruginous stained feldspars and dark silicates traversed by hexagonal apatite needles.

The section is composed of feldspar (plagioclase chiefly) pyroxene, secondary hornblende, and magnetite. Much limonite occurs, lining the fissures and staining the feldspars. The pyroxene is brownish and has the characteristic fractures and general characters of augite, but in portions of its mass the structure of diallage is clearly to be observed. as a secondary structure arising through the alteration of the augite.

126. *Black beach, lake Superior, near Beaver bay.*

A coarsely crystalline dark gray rock, composed of feldspar of a gray or reddish color, black diallage, as well as that showing the schillerization of bronzite and magnetite.

In the section the feldspar is seen to be considerably altered, but much of it shows polysynthetic twinning according to the albite and pericline laws. Quite an amount of plagioclase of secondary origin was observed. The diallage is of a pale yellowish brown color, when clear, and much like that of No. 221, but it has been largely altered to a dirty green fibrous product, arranged parallel to the basal pinacoid. In places the groundmass has been altered to a confused mass of viridite. a rusty brown fibrous product, quartz, etc. The association of the quartz and rusty fibers give rise to the beginning of a structure, which, when continued, produces the graphic granite or eozoön structure observed by the writer* in the rocks of Keweenaw point and elsewhere, which structure was later studied and figured by Irving.†

In this altered groundmass occur dirty green pseudomorphs after diallage and some possibly after olivine.

* Bull. Mus. Comp. Zool., 1880, vii, 113-120: Lithological Studies, 1884, p. 173.

† Copper-bearing Rocks, 1883, pp. 112-24.

The secondary feldspar is very clear and contains numerous microlites, which can be seen in other portions of the section.

No. 222. *East of Brule river.*

Is a rock of the same character except that the schillerization of the diallage has proceeded much further, causing it to easily cleave into micaceous looking plates parallel to the basal pinacoid, while much secondary quartz and viridite are to be seen.

One strange form occurring in this rock is shown in Fig. 2, Plate VI. At the right toward the bottom of the figure is a secondary plagioclase feldspar containing magnetite granules and some dust of the altered rock material. This serves as a nucleus about which is arranged, with a somewhat radiated structure, a grayish-brown irregular mixture of altered rock material, ferrite, kaolin, fibrous matter, viridite, magnetite, much quartz, etc. It also contains clear colorless patches of quartz holding a little magnetite and microlites. Surrounding this is a grayish brown border of secondary diallage showing for the most part a radiated fibrous structure. The fibrous structure or schillerization was produced by alteration and those portions of the diallage which have it are stained gray, yellowish, greenish, reddish or brownish as the case may be. Some portions of the diallage show no trace of the fibrous structure or cleavage and are practically unaltered. The irregular whitish patch at the bottom and left of the figure is plagioclastic feldspar containing viridite, kaolin, magnetite, etc. Large masses of magnetite occur and are shown in the figure.

121. *East of Brule river.*

Has a section of a diabasic character: lath-shaped plagioclase crystals with much augite and a little olivine, mainly altered to a dark reddish and yellowish brown serpentine. Besides these there occur magnetite and greenish chloritic secondary products. This is placed with the gabbros on account of the development in the augite, by alteration, of the common diallage cleavage.

759. *Mountain south of Ogishkie Muncie lake.*

A grayish green coarsely crystalline rock, composed of feldspar, hornblende, and magnetite.

In the section the rock is seen to be greatly altered, retaining no trace of diallage, the pyroxenic constituent being replaced by a green fibrous hornblende. The feldspar retains its plagioclastic characters in places only, and it has largely been filled with secondary quartz and orthoclase.

648. *N. W. cor. T.* 62, 2 *E.*

Is a coarsely crystalline dark dioritic rock, macroscopically composed of reddish or grayish feldspar, magnetite, diallage and hornblende.

Under the microscope it is seen to have its diallage partially altered to chlorite, biotite, magnetite, green and brown hornblende, etc. The apatite crystals have also been changed to a greenish viriditic substance, while much secondary quartz, part of which has the graphic form, is to be observed in the altered feldspar. Secondary apatite (?) microlites are abundant.

672. *Hill near south shore of lake Abita.*

Is a coarsely crystalline rock, of a dark grayish brown color and composed of reddish and gray feldspar, magnetite, diallage, and hornblende.

The section is composed of partially altered plagioclase, partially changed to diallage, magnetite, and secondary hornblende. Considerable secondary eozoön or graphic quartz was observed in the feldspathic material giving the rock there the structure of a graphic granite. Some pyrite occurs associated with the magnetite which, in places, is surrounded and penetrated by the pyrite. Considerable apatite was observed in the section.

649. *Sec.* 36, *T.* 63. 1 *E.*

Is a reddish crystalline rock composed of predominating reddish feldspars with some grayish ones, and hornblende and magnetite.

In the section the feldspars are seen to be greatly altered, the grayish ones retaining, however, their outlines, but showing principally aggregate polarization. Much of the section is now a reddish brown fibrous mass with irregular secondary quartz masses scattered through it. The diallage has been mostly altered to a greenish chloritic mass and to a yellowish brown fibrous material, which sometimes extinguishes parallel to the inclosed

diallage remains, and at others has a separate plane of extinction. Apatite in well marked crystals is abundant.

156. *East of Baptism river.*

A disintegrating crumbling rock, coarsely crystalline and of a reddish color. Composed macroscopically of reddish and grayish feldspar, magnetite, diallage sometimes showing schillerization, and biotite.

The section is composed of reddish brown and gray feldspars and magnetite. The feldspars are all altered and kaolinized and partially replaced by quartz, etc.

Analysis of this rock, made by Profs. J. A. Dodge and C. F. Sidener, gave the following result:

SiO_2	50.86
Al_2O_3	15.72
Fe_2O_3	9.77
FeO	2.48
CaO	10.52
MgO	3.55
Na_2O	3.89
K_2O	0.90
H_2O	2.53
	100.22

The analysis was made at my request for the purpose of ascertaining if so great an alteration made any essential difference in the chemical constitution of the gabbros, with the result that it did not in this case.

644. *T.* 62 *N.* 1 *E.*

A coarsely crystalline granitoid rock, of a pale reddish brown color, and composed of flesh colored feldspars, magnetite, hornblende, quartz, and apatite.

In the section the feldspars are seen to be much altered showing aggregate polarization, while much of the area is taken up by the graphic arrangement of secondary quartz in a feldspathic groundmass. Considerable augite with some diallage was observed. The latter is largely altered to a greenish brown fibrous product, which retains the extinction point of the remaining diallage. Part of the augite shows the common prismatic cleav-

age but in other portions of the same crystal the fibrous alteration of the diallage is to be seen, thus supporting the views of those authors who hold that diallage is derived in part at least from the alteration of augite, (ante, page 00). Apatite and magnetite are common and some biotite was observed.

From this section and others observed the writer has but little doubt that most, if not all, of Irving's augite-syenytes are altered conditions of gabbro and diabase the same as this rock is. This view Irving's language would indicate he partially shared.*

300. *S. W.* ¼ *Sec.* 30, *T.* 65, 3 *E.*

A dark grayish brown crystalline rock, showing the action of weathering and composed of feldspar, magnetite, apatite needles, and dark silicates.

The section is composed of feldspar, pyroxene, quartz, hornblende, viridite, apatite, and magnetite. The feldspar has been kaolinized and filled with scales, and granules, as well as partly replaced by secondary feldspar and quartz. The plagioclastic twinning is still visible in some of the altered feldspars as well as in some of the secondary ones. The quartz is arranged in the graphic or eozoön form in the kaolinized feldspar and some times with the viridite. The pyroxene apparently lies between diallage and augite, but nearer the latter. It is altered to diallage which passes into a dirty, yellowish brown viridite, which extends across the longitudinal cleavage.

The viridite, on its edges, has passed in places into hornblende and while the structural lines of the diallage and viridite are perpendicular to the augite cleavage, the cleavage lines of the hornblende coincide with the prismatic cleavages of the pyroxene. Neither of these secondary products agree in orientation with the pyroxene, although the widely separated parts of the hornblende do agree among themselves. The apatite needles are found to extend through the altered and secondary feldspar, quartz, and viridite, and thus these needles are known to be of secondary origin themselves.

Plate VII, Fig. 1 shows the structure of the augite and its alterations described above.

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* Copper-bearing Rocks, 1883, pp. 112-124.

263. *Wauswaugoning bay.*

A dark grayish and reddish brown crystalline rock, composed macroscopically of reddish and grayish feldspar, pyroxene, hornblende, biotite, magnetite, quartz, and calcite.

The section has its pyroxene largely altered to biotite, hornblende, and viridite. Much secondary feldspar of a plagioclase type occurs, but the primary feldspar appears to have been largely, if not entirely, replaced by the graphic or eozoön quartz, and fibrous kaolinized feldspathic material. Secondary quartz in irregular grains, besides the graphic form, is quite abundant, while both the quartz and feldspar are filled with microlites (apatite?)

Plate VII, Fig. 2, shows the structure of one of the altered diallage crystals. The diallage is in the form of a core surrounded and penetrated by a greenish viridite which traverses the irregular cracks of the diallage. The viridite passes on its outer edge into a greenish hornblende which is the second step in the diallage alteration. Apatite and magnetite are common, and some biotite was observed.

Fig. 1, Plate IX indicates the graphic or eozoön stage in the alteration of this rock, while Fig. 2 of the same plate shows a more highly altered or a biotite-hornblende-granite form. The quartz contains microlites and fluid cavities.

225. *East point of Double bay.*

Is a rock almost identical with 263 except that no calcite was seen in it.

675. *Brule Mt.*

Is a reddish brown rock, somewhat finer in its crystalline structure than the two preceeding, but otherwise similar.

292. *North side of Pigeon point peninsula.*

A reddish granitoid rock, composed of reddish feldspar, biotite, quartz, magnetite, and calcite. The thin section is made up principally of feldspar, quartz, pyrite, biotite, apatite, chlorite, and magnetite. The feldspar is kaolinized and stained with ferric oxide. While from the structure of the crystals but little doubt exists that they were originally plagioclase, no proof that

such was the case, was obtained. The quartz is in irregular masses in the section, but in the hand section in connection with the calcite it is seen in distinct crystals. It contains numerous fluid cavities with moving bubbles and also microlites. The latter show frequently the hexagonal form and common structure of apatite. That the quartz is all secondary in the section is told by its possessing the same eozoön or graphic structure in places that the secondary quartz of other rocks does, also by its replacement in part of the substance of feldspar crystals, whose outlines yet remain distinct. From this it follows that both the fluid inclusions and microlites are of subsequent origin to the original crystallization of the rock — i. e. produced during the process of alteration. *

The biotite is all secondary and is colored green or yellowish brown, according to its advancing stage of formation.

This rock, both macro- and microscopically, could well be classed as a granite and sustains the conclusion to which the writer was driven long ago, that many of the so-called granites are, like the diorytes, the results of the alteration of other rocks both of a basic and acidic nature.

The calcite is all secondary and fills in the rock mass interstitial cavities which are either original, or, as is most probably the case, of secondary origin, arising from the removal of portions of the rock and their replacement by calcite through the medium of percolating waters. No positive proof was obtained from the section that this rock is an altered gabbro in preference to its being an altered form of a more acidic rock. The chemical analyses made by Profs. Dodge and Sidener indicates either that it is an altered form of a more acidic rock or else that its percentages of iron and lime have been lowered and its silica and potash increased, by the alteration, from those of a normal gabbro.† The small content of calcium oxide, compared with the amount seen in the hand specimen, indicates that possibly the analysis was made from too small a portion of the rock to give the average composition of the rock as a whole.

The analysis is given below:

$Si\ O_2$	61.09
Al_2O_3	15 34

* Bull. Mus. Comp. Zool, 1880, vii, 39, 51, 114, 117. Lithological Studies, 1884, p. 46.

† Lithological Studies, 1884, pp. 186-189.

Fe_2O_3	5.74
FeO	3.69
CaO	3.10
MgO	1.33
Na_2O	3.41
K_2O	3.65
H_2O	1.80

756. *South of Ogishkie Muncie lakes.*

Also is an almost entirely altered rock with a little diallage and only traces of the plagioclastic striation remaining in the feldspar. The magnetite shows, in places, the titaniferous alteration to "leucoxene" and is for the most part surrounded and largely absorbed by the viridite and hornblende.

The hand specimen is a greenish crystalline rock, composed principally of feldspar and hornblende.

305. *Outlet to North lake.*

Is a dark gray typical dioryte composed of a coarsely granular mixture of grayish and flesh colored feldspar with black hornblende. The section is composed of feldspar, biotite, hornblende, quartz, diallage, magnetite, apatite, titanite, and zircon.

A large crystal of diallage having a longitudinal section shows more or less of a greenish alteration extending along the fissure planes. It also contains small rounded masses of secondary biotite. The alteration is most strongly marked on the edges of the crystal. Here nearest the centre is a green irregular band of a mineral in the process of formation, while outside of this, the same mineral forms a darker green band with a longitudinal cleavage like that of amphibole. This second band contains apatite crystals, while partially in this band and partially exterior to it are irregularly scattered grains of secondary quartz. Outside of the green mineral lies considerable biotite, which is also scattered through the section, but is chiefly aggregated about the altered diallage. Some of the biotite shows an irregular cross banding, traversing across the cleavage planes at a slight angle. This banding shows very indistinctly in common light, and when the section is right side up with the polarizer on, it is likewise indistinct. Between crossed nicols this banding is distinct in every position except when the longitudinal section is parallel to the plane of vibration of the polarizer. But if the

section is reversed the banding is distinct in common light, and also with the polarizer on, and in every position between crossed nicols except when its longest direction is parallel to the plane of polarization of the lower nicol. This banding is attributed to a furrowing produced on the back of the section by the coarse corundum used in grinding it.

The green substance surrounding the diallage and formed from its alteration is irregularly interlocked with the diallage, and the plane of extinction of the two minerals correspond. However, it is only slightly and sometimes not at all dichroic, but still is referred to hornblende, not only on account of its cleavage but also on account of finding true hornblende in exactly the same relation to another diallage crystal in the section, but a crystal that has suffered alteration to a greater degree. The steps in the alteration shown by the different diallage cores irregularly interlocked with the hornblendic substance and gradually passing into it are as follows: 1st. A palish green substance, not dichroic and destitute of cleavage. 2d. A deeper green substance having a longitudinal cleavage, but not dichroic or only slightly so. 3d. The same dark green substance, (all being connected) but of a somewhat darker green color, and dichroic, varying from a slightly yellowish green to a dark green. 4th. A well-marked light hornblende, with not only the hornblende cleavage in a longitudinal direction, but also across the longer or vertical axis. This is dichroic varying from a yellowish brown to a dark brown color. These changes resemble those shown by Williams in the Baltimore gabbro.

The first three stages are to be seen united about a single diallage core, as are also the third and fourth stages.

A little epidote was seen, as well as a few minute crystals, resembling zircon in form, but which have an oblique extinction with a feeble chromatic polarization.

One quartz crystal was seen which had replaced a plagioclase, and still retained in its interior irregular cloudy masses of the kaolinized feldspar, while in part of the crystal the plagioclastic twinning lines remain distinctly visible in common light. The quartz grains contain grains and crystals of magnetite, minute plates of biotite, microlites, trichites, etc., all of which must be of secondary origin as the quartz is.

Part of the feldspar retains the microlites and brown plates

arranged parallel to the crystallographic plane as seen so commonly in the feldspar of gabbros. Some titanite grains were also observed.

Plate VIII, Fig. 1, shows one of the smaller altered diallage crystals containing greenish plates on the interior, and surrounded by a green hornblende on the exterior which passes into brown hornblende, showing prismatic cleavage and into brown biotite bearing magnetite. A little yellowish epidote occurs in the upper portion of the figure.

780. *Between Duck and L. lakes.*

Is a yellowish gray granitoid rock, composed of feldspar, magnetite, biotite, and hornblende. It is so altered that the transition is complete, except in the case of a few pyroxene grains, so as to form a quartz-diorite, although it contains much orthoclase and some biotite and might thus be styled a granite. The orthoclase, quartz, biotite, and hornblende all appear to be secondary, as are probably the numerous microlites by which they are traversed.

816.

The section is granitoid in structure and composed of feldspar, hornblende, quartz, viridite, magnetite, chlorite, epidote and apatite. The feldspar is much altered and contains kaolin, chlorite, and colorless micaceous scales. The hornblende is both green and brown, the latter color simply indicating a further stage in the alteration of the pyroxene to a perfect hornblende than the green state denotes, and the former is often found forming a border on the green hornblende. Quartz is abundant in large irregular grains and the rock is now a quartz-dioryte, but the writer believes it to be an altered gabbro or diabase, as its structure is like that of known altered forms of these rocks.

801. *2½ miles S. E. of St. Cloud.*

A dark gray coarsely crystalline rock, composed of hornblende, biotite, pinkish and gray feldspar, quartz, and magnetite.

Under the microscope it is seen to be composed of the above

minerals with titanite, apatite, and microlites. The feldspar is in part plagioclase and in part orthoclase but in both cases the feldspar material seems to be of a secondary origin replacing other feldspars and in part retaining their cloudy kaolinized material and striations. The feldspar also in places shows some of the common inclusions found in the feldspar of gabbros. The hornblende is green, like that of No. 305. and filled in the same manner, but more abundantly, with apatite. Some of the biotite shows the polarization phenomenon produced by the grinding, as the preceding No. 305, but the bands very irregularly cross one another. The quartz is like that of the preceding. While this rock, in its present stage, makes a good representative of a biotite-hornblende-granite, it is believed to be but a further stage in the alteration process than that shown by No. 305. In both we have the same general characters in their minerals, except that in No. 305 part of the diallage remains, while in No. 801 it has been entirely changed. Macroscopically, this rock is like part of the preceding rocks, and this solution of its structure would account for the later origin of the quartz and its impression by the other minerals in all so-called granites having the same origin as this.

One portion of the rock is darker than the other, and an analysis was made of each portion by Profs. Dodge and Sidener, with the following results:

	Light Portion.	Dark Portion.
$Si\,O_2$	61.19	58.77
Al_2O_3	15.22	13.12
Fe_2O_3	3.20	5.45
$Fe\,O$	3.55	6.87
$Mn\,O$	trace	trace
$Ca\,O$	7.94	5.99
$Mg\,O$	2.38	4.93
Na_2O	3.17	1.94
K_2O	2.62	2.8[illegible]
H_2O	0.40	0.4
	99.67	100.[illegible]

These results indicate either that during alteration the b rocks become more acidic by alteration, as the writer shov was the case for the peridotytes, or else that this rock is fi

* Lithological Studies, 1884, pp. 186-189.

more acidic group than the basalts, and that the writer has wrongly placed it with the altered gabbros.

364. *Burnside lake.*

Is a crystalline gneissoid rock, possessing a banded structure, and composed of pinkish and grayish feldspar and hornblende.

Under the microscope the section is seen to be composed of kaolinized feldspar, partially replaced by quartz, and much green amphibole, with a little biotite. The amphibole is in part a green actinolite. One crystal pseudomorph was seen composed of a light green centre of irregularly arranged amphibole plates, with a dark green border of amphibole. This closely resembles an altered diallage, the central portion being changed last.

789. *Temperance River lake.*

Is a dark gray and greenish black rock, composed of magnetite, gray and pink feldspar, and greenish hornblende.

The section shows that the feldspar is much kaolinized, retaining the polysynthetic twinning bands only in places. The amphibole is both green uralite and actinolite. The amphibole is filled with abundant apatite crystals, while the feldspar also contains them to some extent.

707. *Mayhew lake.*

Is a dark grayish green crystalline rock, composed of grayish feldspar, quartz, hornblende, and some chlorite. In the section it is seen to be composed of plagioclase and secondary hornblende (uralitic), biotite, quartz, apatite, and chlorite. Only a small amount of biotite was observed.

334. *Pipestone Rapids.*

A dark grayish and greenish black rock, composed principally of hornblende with some feldspar. Under the microscope it is seen to be composed of kaolinized feldspar and secondary hornblende, quartz, titanite, etc. One quartz pseudomorph after plagioclase retains the plagioclastic striation in common light and cloudy patches of the kaolinized material. This is considered by the writer to be an altered gabbro, judging from its structure, although it may be a sedimentary hornblende schist

or gneiss. The structure of this rock is shown in Plate VIII, Fig. 2. The upper portion is composed of quartz grains containing cloudy kaolin granules from the altered feldspar, while the lower central portion is the quartz showing the striations of plagioclase with kaolin material.

Brown and green hornblendes are on the right and left, with yellowish brown titanite grains in the quartz at the bottom of the figure.

693. *West end of Poplar lake.*

A yellowish gray crystalline rock, composed of plagioclase and magnetite. Powder magnetic. Under the microscope it is seen to be composed of plagioclase with some probable orthoclase, olivine, and magnetite. The magnetite is surrounded in part by a ferruginous looking border containing, if not entirely composed of, biotite fibres standing at right angles to the peripheries of the grains. A little "leucoxene" was abserved.

5. *St. Paul & Duluth Railroad Station, Duluth.*

A dark, coarsely crystalline rock, containing considerable pinkish feldspar.

The section is composed of plagioclase, diallage, magnetite, apatite, and secondary quartz, hornblende, and chlorite. The diallage is in part changed to a dark, cloudy substance, while the feldspar is much kaolinized.

688. *Cross lake.*

Is a dark compact but coarsely crystalline rock, composed of feldspar (pinkish and grayish), apatite, magnetite and pyroxene.

Under the microscope this rock is seen to have its diallage much altered principally to a uralitic product. The plagioclase, in places, exhibits its twinning only at the point of extinction, as was shown by the writer to be the case with the plagioclase of the Bishopville meteorite.*

The feldspar is also much altered and the section in places shows the structure of graphic granite or the eozoön character

* Am. Jour. Sci., 1883, (3,) xxvi 34; Lithological Studies, 1884, p. 200.

occuring in the granites and felsites of Keweenaw Point. In No. 688 this structure is evidently produced by the aggregation of the silica in the midst of the feldspar through the medium of the percolating waters, while the remaining feldspar itself is much changed and stained by ferruginous material. Much apatite occurs in the section.

694. *South shore of Mayhew lake.*

Is a grayish black crystalline rock, composed of feldspar and a large amount of titaniferous magnetite.

The section is composed of plagioclase, some possible orthoclase, diallage, olivine, and magnetite. The latter is partially surrounded by well marked biotite borders, while it contains inclusions of the same. One of the olivines, which is apparently a unit in common light, its form and fracture lines indicating this, is seen in polarized light to be made up of four individuals. A little biotite occurs, but it is not attatched to the magnetite.

704. *Mayhew lake.*

Is a darker rock than 694 and is richer in magnetite. The section is seen, however, to have the same composition and structure as No. 694. Part of the diallage shows also the cleavage of augite.* Biotite is present, holding the same relation to the magnetite as before, while the section is somewhat more altered than the preceding. The diallage is in places quite cloudy as the result of this alteration with the development of magnetite needles and dust parallel to its cleavage planes.

703. *Pewabic island.*

Is a black compact iron ore composed of predominating magnetite, with plagioclase, olivine and biotite. The biotite, as before, is in borders surrounding the magnetite or inclosed in it. Besides the quite abundant biotite, these borders are sometimes composed of a clear, feebly polarizing substance of unknown character but probably an early stage in the formation of biotite, the general structure being shown in Plate VI, Fig. 1.

The feldspar shows, in polarized light, that it is composed of large crystals in which the magnetite is lying, forming an

* Lithological Studies, 1884, p. 145.

irregular sponge-like mass of iron ore like that in the Cumberlandyte.*

651. *Sec.* 36, *T.* 63, 1 *E.*

Is a dark, coarsely crystalline rock, also containing much magnetite. The section is composed of feldspar, part of which is twinned according to the albite and pericline law, augite, diallage, magnetite and olivine. The pyroxene is yellowish brown, and while the chief portion of the section is coarsely crystalline, part is of a fine grained basaltic texture and composed of divergent lath-shaped plagioclases with the interspaces filled with augite and magnetite granules.

787. *South slope of the Mesabi range.*

A grayish medium-grained rock, composed principally of a clear glassy feldspar, holding brownish olivine, diallage and magnetite. The section is composed of clear feldspar, holding yellowish brown olivine, darker brown enstatite, and magnetite.

The feldspar shows a clear brilliant polarization, while the polysynthetic twinning according to the albite-pericline law is marked even in common light. The fibrous alteration has begun to appear along the cleavage planes and fissures giving it, in places, the common cloudy appearance seen in feldspars of considerable age. The olivine stands next in abundance to the feldspar and is much fissured with a yellowish ferrnginous staining along the fissures, and sometimes even extending through the entire mass of the mineral. It contains some magnetite, part of which is secondary, while the olivine itself appears to be foreign.

The enstatite is mostly built out upon the olivine grains as an apparent continuation of them but only rarely do they correspond in optical orientation. The enstatite shows the beginning of alteration, indicated by a brownish color, and the development of fine smoky ferruginous bands parallel to the principal cleavage. It also has an irregular cross fracture. The magnetite is often bordered by forming fibrous biotite.†

This rock answers to the olivine-noryte of Rosenbusch, and in its structure it somewhat macroscopically resembles some of the

* See Lithological Studies, 1884, pp. 75-81; Plate I, Figs. 5 and 6; Plate II, Figs. 1, 2 and 3.

† Irving, Copper-bearing Rocks, 188, p. 51; Hawes, Lithology of N. H. 1878, p. 205; Wadsworth, Lithological Studies, 1884, p. 77.

basaltic meteorites. Fig. 1, Plate III, shows the structure of the rock.

512. *N. E.* ¼ *Sec.* 25, *T.* 50, 15.

A dark gray crystalline granular rock, composed of feldspar, magnetite, and diallage. The section is that of a clear typical gabbro of the finer grain. The section is stained yellowish brown in places by oxide of iron especially along the fissures and in the vicinity of the magnetite. Some secondary minerals, chiefly biotite, were observed.

715. *Poplar lake.*

Is a grayish granular rock, composed of plagioclase, some olivine and pyroxene, part of which has the cleavage and optical characters of enstatite and part that of diallage.

692. *South shore of Little lake.*

Is a grayish compact rock, composed of plagioclase, a little magnetite and irregular masses of diallage, holding rounded and irregular patches of enstatite. Both are more or less cloudy from the secondary magnetite dust and needles.

Fig. 2, Plate II, shows the structure and relations of the banded enstatite in its rounded grains inclosed in the diallage, the latter being cut by the colored feldspar.

786. *A brown crystalline granular rock.*

The section is composed of a fine granular mixture of plagioclase, orthoclase, augite, diallage, enstatite, biotite, magnetite, and microlites. The structure is the granular structure seen in rocks owing to the recrystallization of their original materials. The feldspar contains much of the black dust and microlites commonly seen in the feldspar of gabbros.

777. *L. Lake.*

Is grayish brown porphyritic rock resembling that found in Gloucester, Mass., and belongs to the gabbros. The section is composed of large plagioclase crystals, lying in a crystalline granular groundmass of diallage, augite, biotite, uralite, mag-

netite, plagioclase, orthoclase, and some quartz. All are in more or less rounded grains, and the general structure of the groundmass is that of one which has been formed by the recrystallization of its materials, i. e. the augite and diallage are the remnants of larger crystals, while much of the feldspar and all of the quartz, biotite, and uralite are the results of alteration. The biotite and uralite are formed from the pyroxene. The larger plagioclase crystals are filled with elongated dark needle-like shapes which are arranged parallel to the twinning, clinopinacoid, and other crystal planes. These needles polarize with a bright, yellowish brown color, like thin biotite plates. On further examination some sections are found cut obliquely to these needles, when they are found to be elongated, oval, yellowish brown plates of biotite. These plates are evidently an alteration product of the feldspar itself.

Plate IV, Fig. 1, shows the granular structure of this rock with the brown biotite on the right and greenish hornblende at the bottom of the figure. The section in places shows the characters of a dioryte or hornblende schist.

595. *Silver islet.*

A grayish crystalline rock, taken from a diamond drill core.

The section is composed of plagioclase with much enstatite, part of which closely approaches the proto-bronzite of Prof. Judd, * some diallage or augite with much biotite, quartz, etc. The enstatite is altered in part to a dull, dark green bastite, and to biotite. In the more highly altered portions of the section the quartz forms the graphic or eozoön structure, which, with the biotite, feldspar, and microlites, causes these parts to be granitic. A few pseudomorphs, apparently after olivine, occur, so it is doubtful whether this rock would fall under the noryte or olivine-noryte of Rosenbusch.

691. *Little lake.*

The section is composed of feldspar, diallage, magnetite, and olivine and is similar to No. 692. The olivine is largely altered to a yellowish green fibrous serpentine. This alteration has proceeded in a peculiar manner. In some of the olivine grains

* Quart. Jour. Geol. Soc. 1885, p. 371.

bands of black and brown plates and needles, which for the most part are arranged parallel to the axis of the greatest elasticity, although a few are at right angles to it. The olivine also has two well-marked cleavages parallel to these directions, along which lines the serpentinous alteration extends. But as the alteration is the greatest at right angles to the line of greatest elasticity, the more highly altered olivines present an alternate series of parallel bands of serpentine and partially altered olivine. In some cases the planes of greatest alteration coincide with the line of greatest elasticity, while in some of the entirely changed olivines the serpentine is arranged in fine fibrous parallel bands occupying the entire surface. The diallage contains much magnetite dust and grains arranged mostly along the cleavage lines, as a product of alteration.

Plate XII, Fig. 2, shows the structure of some of the less altered olivines.

700. *Mayhew lake.*

Is a compact dark grayish crystalline rock, composed of diallage, olivine, feldspar, and magnetite. Considerable of the secondary biotite is found associated with the magnetite and diallage. This section has its minerals somewhat altered, the magnetite dust and grains being quite abundant in the diallage, while a chloritic-like vein traverses the section.

Plate III, Fig. 2, shows the general structure of the rock with its brownish diallage, yellowish altered olivines, black magnetite, reddish brown biotite in the diallage and bordering the magnetite, and colorless feldspar.

714. *South of Tucker lake.*

Is a grayish crystalline diabasic rock, whose section is seen to be composed of plagioclase, diallage, olivine partially altered to serpentine, orthoclase, etc. The diallage contains much secondary magnetite dust and needles.

698. *Mayhew lake.*

A compact gray crystalline granular rock, composed of diallage, feldspar, and magnetite. Considerable of the feldspar is unstriated, and the arrangement of the minerals is like that commonly seen in rocks that have recrystallized through the agency of per-

colating waters, i. e. the present mineralogical composition and structure appear as secondary rather than primary, the same as No. 777, which is figured in plate IV, Fig. 1.

705. *Mayhew lake.*

Is a dark gray crystalline granular rock, containing distinguishable feldspar and biotite. It is macroscopically diabasic. Its thin section under the microscope shows an irregular aggregation of short crystals, with rounded or irregular outlines, as seen in Nos. 777 and 698, which marks many rocks whose present structure is due in part or a whole to the recrystallization of its constituents under the influence of water action. The pyroxenic constituents, which may be the remains of original crystals, are in short, irregular, ragged crystals and grains considerably altered and belonging to enstatite. The feldspar is in part plagioclase and in part orthoclase, while magnetite, in part secondary, and secondary biotite and quartz are quite common. The rock is metamorphic but in all probability a metamorphosed eruptive instead of a sedimentary one..

511. *Miller's Creek.*

Is a fine grained crystalline granular rock of a diabasic character and of a dark gray color, forming a contact with a fine grained reddish micro-granite.

The sections are composed of feldspar, diallage and magnetite with secondary quartz, biotite, hornblende, apatite, and amphibole microlites. A few grains and crystals of Zircon and titanite were observed. The rock is quite altered but the alteration is greater in the section taken furthest from the contact. The diallage contains the common black tabular and rod-like inclusions, which in general are in parallel lines forming angles of from 80° to 90° with the orthopinacoidal cleavage. These inclusions appear here as one step in the alteration of the diallage, and they disappear in direct proportion to the perfection of the orthopinacoidal cleavage. This cleavage shows first on the edges or thinner portions leaving the black microlites in the interior; but in the crystaline grains in which the cleavage extends throughout, the microlites are generally entirely obliterated and the grain shows a cloudy felty structure.

514. *S. W.* ¼ *Sec.* 22, *T.* 50, 15.

A dark grayish brown rock, composed of feldspar and olivine. The section is formed of plagioclastic feldspar and olivine with a little diallage. The feldspar is somewhat cloudy from kaolinization, and the olivine is in part altered to a yellowish serpentine. The diallage is more or less filled with magnetite dust arranged in bands mostly parallel to the orthodiagonal cleavage although sometimes seen to be oblique to it. These sections closely approach the characters of forellenstein, and the diallage is in so minute a quantity the specimen could well be called that rock, which is simply a modification of gabbro. Fig. 1, Plate V, shows the nearly unaltered condition of the rock with a few irregular bands crossing the olivine grains, while Fig. 2, Plate V, shows a highly altered condition of the olivine in the same section.

513. *N. W.* ¼, *N. E.* ¼ *Sec.* 27, *T.* 50, 15.

Is composed mainly of feldspar and olivive with some magnetite. A very little diallage was observed in one section. The feldspar is chiefly plagioclase, although a little apparent orthoclase was seen. The olivine is of a greenish yellow color, and only slightly altered, but in places it shows distinct pleochroism varying from greenish yellow to a reddish brown through a yellowish brown. This is then a forellenstein.

Another section, incorrectly numbered 670, is similar in character to the above and has a little dichroic diallage, the color passing from a yellowish to a brownish.

814. *East of Beaver bay.*

A greenish brown coarsely crystalline rock, composed of plagioclase feldspar and some altered olivine, changed to serpentine, and thus comes under the head of forellenstein.

818. *East side of Splitrock point.*

Is a grayish crystalline granular rock and in places is altered to a reddish feldspar.

The sections are composed of plagioclase and olivine altered to greenish serpentine, with some quartz and other secondary products, thus forming a forellenstein.

287. *Pigeon point.*

Has a section composed of plagioclase, diallage, magnetite, altered olivine and other secondary products. The olivine is replaced by reddish and yellowish brown serpentine showing the usual network or "Maschenstructur" of serpentine replacing olivine along a network of fissures. The diallage has suffered considerable alteration, is of a cloudy brownish color and in part replaced by biotite, chlorite, etc.

697. *Mayhew lake.*

Is a dark, somewhat rusty, brown rock, containing feldspar and biotite. The sections of this rock are composed of olivine, diallage, feldspar, magnetite, and secondary serpentine, hornblende, biotite, chlorite, etc. In its general appearance it is closely allied to wherlyte and picryte, but although its feldspar is subordinate to the other minerals, yet it contains sufficient to carry it under gabbro. The olivine, in part, is clear, fissured, and traversed along the fissures by bordering serpentine or ferruginous staining. Other olivines are nearly or entirely replaced by the greenish serpentine. The diallage contains some of the black needle-like inclusions, etc., but for the most part it has been changed to a brown felty cleavable mass; or to chloritic and amphibole products. The feldspar in part is much altered. The biotite varies from a deep reddish brown to a brownish yellow color—colors to which its dichroism corresponds. The biotite is largely associated with the magnetite, often surrounding the grains of the latter.

776. *Between Duck and L lakes.*

Has its section composed of partially altered diallage, feldspar, magnetite, and secondary quartz, hornblende, biotite, etc. The diallage is filled with the usual black needles and grains, which also occur abundantly in the feldspar. Part of the feldspar appears to be of a secondary origin, while numerous amphibole microlites of secondary origin extend through the quartz and feldspar. Fluid cavities occur in the quartz. The hand specimen is a brownish gray, granitoid or dioritic rock, with tabular pinkish feldspar. It shows surface weathering.

781. *Wind lake.*

A gray crystalline granitoid rock, composed of gray feldspar, biotite, hornblende, etc. Its section is similar to the preceding No. 776, but it has few microlites. The diallage has fewer inclusions than that of No. 776, and is largely altered to hornblende and biotite. The quartz is quite abundant, and the biotite is largely associated with and surrounds the magnetite. The analysis by Professors Dodge and Sidener gave the following result.

$Si\ O_2$	53.43
Al_2O_3	13.81
Fe_2O_3	5.08
$Fe\ O_2$	9.86
$Mn\ O$	trace
$Ca\ O$	8.25
$Mg\ O$	4.64
Na_2O	2.51
K_2O	1.12
H_2O	0.27
	98.97

DIABASE.

664. *Two miles from Horseshoe bay.*

Has a section composed of brownish augite dissected by divergent feldspars and containing magnetite and some secondary products. As a rule the augite is a clear brown or yellowish brown, containing rows of magnetite, vapor cavities, and other inclusions arranged along fissures. It also shows in places the fine parallel cleavage of diallage. This is usually towards the edges or in altered portions of the crystal. Yet these points are of very minor importance compared with augite proper, which occupies about two thirds of the section. The feldspar is plagioclase and in some places shows kaolinization. Both the pyroxene and the feldspar are traversed by numerous fissures which are bordered by yellowish and brownish ferruginous stainings. A serpentinous material forms brownish patches which may possibly be pseudomorphs after olivine, but it, with apatite, apoea rs

oftener to be formed by the alteration of the original interstitial base of rock.

The section is traversed in one portion by a brownish and greenish vein of serpentinous material.

The magnetite is either of foreign origin or was the earliest mineral to crystallize. This is followed by the feldspar, and lastly by the augite; the interstitial base being left an uncrystallized and easy altering material. In structure and character there is no reason this rock should not be called a gabbro, except that the pyroxene is essentially augite. The structure is decidedly granitoid.

819. *Hill near the mouth of Silver creek.*

Is a grayish brown rock having a resinous lustre. The section is composed of lath-shaped plagioclases cutting through irregular masses of augite, also olivine grains and magnetite. The feldspars are quite clear but are in places somewhat kaolinized and contain a viriditic product as well as the remains of inclusions of the globulitic base. Trains of vapor cavities extend in the feldspar and are continued with and through the augite. This mineral is quite clear, of a brownish color, and shows its characteristic irregular cleavage.

The olivine is partially inclosed in the augite and is much fissured, with the border of the fissures formed by greenish, yellowish, and brownish serpentine, which also borders the grains and sometimes extends through quite a portion of their mass. The olivine is foreign and possibly the magnetite is the same, but if not, it has been the first mineral to crystallize from the magma followed by the feldspar and lastly by the augite, although the last two were nearly, if not quite, contemporaneous.

In one portion of the section the twinning of the plagioclase is seen to be dependent upon the pressure exerted by the solidifying augite.

141. *East of Palisade creek.*

A dark, grayish-brown crystalline rock with a resinous lustre, and contains vitreous feldspars.

The section is much like that of the preceding except that no distinguishable olivine was observed. As a secondary product

occurs, a radiated fibrous greenish material with aggregate polarization, much like that usually seen in forming chalcedony. Another secondary product is seen, which is of a brown or yellowish color, and closely like the hisingerite* of the Ovifak basalt. The green product is associated with the feldspar in a manner to indicate that it is formed by the alteraation of included and interstitial base, while the brown may possibly represent the olivine, as well as some altered augite.

228. *Double bay.*

A brown crystalline rock, weathering to a rusty brown.

The section is granitic in structure and composed of divergent lath shaped plagioclase, with much augite and magnetite. The section also contains abundantly an orange brown material resembling palagonite, which is partly isotropic and partly anisotropic. It apparently has been formed from the alteration of an interstitial basaltic base.

90. *East point of Sucker bay.*

A dark greenish gray compact crystalline rock.

One section is composed of numerous grains of olivine and masses of augite arranged irregularly in the feldspar which is sometimes in aggregations of crystals and sometimes in divergent lath-shaped blades dissecting the augite. The feldspar contains the remains of an included globulitic base, so commonly seen in the plagioclase of modern basalts.

The olivine is much fissured and more or less altered to a greenish serpentine. Greenish and yellowish brown secondary products, showing aggregate polarization, are common in the section. In another section of the same rock the feldspar contains much of the altered globulitic base, while that mineral is largely in rounded and tabular aggregations of crystals. The olivine is here altered, not only to the greenish serpentine, but also to a brownish yellow form.

90 B. *East point of Sucker bay.*

Is a coarsely crystalline gray rock, with divergent feldspars, holding interstitial dark silicates with magnetite.

* Lithological Studies, 1884, pp. 202-203.

In the hand specimen and section it is like the gabbros. The feldspar is in the so-called saussurite state. It contains much secondary quartz, orthoclase, and scale like plates. Many of the apparently clear unaltered portions show, in polarized light, that they are made up of leaf-like aggregates, while much of the feldspar is too cloudy to affect polarized light. Besides the feldspar, the section contains augite, magnetite, and various alteration products. The interstitial base has been replaced by a greenish chloritic material, greenish, cloudy, and colorless chalcedony and quartz. The augite is also considerably altered in places, while secondary apatite appears. Many of the feldspars, which in places still retain the plagioclastic striation intact, appear in polarized light to be homogeneous orthoclase, that feldspar apparently having in part replaced the plagioclase.

752. *S. E.* ¼, *Sec.* 30, *T.* 65, 6 *W.*

A grayish green crystalline rock, with a dark green groundmass, containing greenish gray lath-shaped feldspars and dark augites.

In the thin section the feldspars are mostly cloudy and kaolinized, although the triclinic character of some is observable in polarized light. The augite is brown and largely altered to viridite, which mineral substance replaces part of the feldspar. Some green pseudomorphs, apparently after olivine, were observed, while more or less actinolite, biotite, and chlorite was seen associated with the viridite and formed from it. Considerable secondary quartz was noticed associated with the feldspar, while microlites are common both in the quartz and augite. Some apatite crystals were seen, as well as "leucoxene" and pyrite.

221. *East of Brule river.*

Is a dark brownish rock, containing pale yellowish vitreous feldspars. Under the microscope the section is seen to be composed of feldspar, pyroxene, quartz, magnetite and the remains of a former unindividualized base. The feldspar is very clear, polarizing with vivid colors. While part appears to be orthoclase, the greater portion is plagioclase, much of which is twinned according to the albite and pericline law. The pyroxene more closely approaches in structure the characters of augite

than those of diallage; and the rock is best classified as a diabase. The former unindividualized base is filled with microlites, and has been altered to quartz, opacite, and a palagionite or hisingerite mineral, which is isotropic and of brownish color. This is similar to that observed by Törnebohm in the Ovifak basalt.* Although no native iron was observed in the rock-section No. 221, this is strikingly similar to some of the sections of the Greenland iron-bearing rock.

223. *Four miles east of Brule river.*

A brown crystalline rock with lath-shaped feldspars. The section is built up of divergent lath-shaped plagioclase crystals with irregular masses of augite and magnetite. The augite shows in many places the cleavage of diallage arising through alteration. A few olivine grains were observed, as well as some dirty greenish brown patches that may represent altered olivine grains. The interstitial base has now been replaced by quartz, a dirty greenish viridite, microlites, etc., giving rise to a rock that might now be called a quartz-diabase.

788. *East side of Burntwood lake.*

A coarsely crystalline rusty granitoid rock, traversed by numerous apatite needles.

The section is composed of feldspar, augite, hornblende, biotite, quartz, apatite, magnetite, etc. The feldspar is altered and kaolinized in part, and is both orthoclase and plagioclase. The augite is of a brownish color, and along its borders, and sometimes throughout much of its mass, has been altered to a greenish fibrous and scaly or leafy substance. This, in places, possesses the characters of green hornblende, and in others those of biotite. The apatite and quartz are clearly secondary, both occuring in the secondary hornblende. The augite and part of the magnetite and feldspar are the only original minerals left.

650. *Sec.* 36, *T.* 63, 1 *E.*

Is a dark grayish brown, somewhat porphyritic rock whose section is composed of lath-shaped and tabular feldspars, with augite, olivine, quartz, and biotite lying in a brownish ground-

* Behang Kongl. Svenska Vetens. Akad Handl., 1878, v, No. 10, pp. 1-22; see also Lithological Studies, 1884, pp. 202-205.

mass. The feldspar is both orthoclase and plagioclase while part is secondary. The groundmass is now the replacement of a former basaltic groundmass, together with part of its porphyritically inclosed minerals. At the present time this groundmass is the same as that of many quartz porphyries, and is composed of a confused aggregation of quartz, feldspar, ferrite, magnetite, microlites, mica scales, etc. The section, in certain portions, with its larger secondary quartz, could well pass for a felsite or quartz-porphyry. The augite is brownish and shows a strong tendency to alter into pale yellowish grains and irregular crystals associated with feldspar and quartz. This is seen most commonly in the vicinity of magnetite masses. The pale yellowish grains and crystals show the general characters of olivine, as well as the interference figures of orthorhombic crystals. They are also positive, with strong double refraction. They are therefore referred to olivine. However their general appearance is slightly different in coloration, etc., from the common basaltic olivines, and this is naturally the case since one can not suppose a mineral formed by secondary agencies to be identical with one formed primarily, even if chemically and mineralogically they are the same. This olivine appears to represent a case parallel to the secondary olivine of the St. Paul's Rocks as described by the present writer.*

Another alteration product is shown in the formation of scales and masses of biotite, which partially replace the augites, which in most cases remain, forming an elongated central band. The augite, in the earlier stages of alteration, is filled with a brown dust and varying from sometimes it is feebly pleochroic, the color chiefly brown to yellow. Apatite microlites are common, not only in the secondary groundmass, but also transfixing the olivine crystals.

652. *Near the Brule river.*

A grayish-brown crystalline aggregation of feldspar, augite, and magnetite. In the section the feldspar is partly altered and replaced by kaolinized material interstitially arranged with graphic quartz. Part of the feldspar is distinctly plagioclase, and part of the augite has been changed to brown hornblende

* Science, 1883, I, 590-592. Lithological Studies, 1884, pp. 123-125.

and brown biotite. Apatite rods and microlites are to be seen associated with the graphic or eozoön quartz.

774. *Duck lake.*

A fine grained crystalline dioritic rock of pinkish brown color. The feldspars are of a gray and pinkish color.

The section is largely composed of feldspar and quartz arranged in graphic or eozoön form. Besides these minerals much magnetite, augite, a little diallage, hornblende, some biotite, yellowish pseudomorphs after olivine or augite, and microlites occur. The augite in places is altered into uralite and at others into brown hornblende, which exhibits the characteristic cleavage. The brown hornblende occupies part of the original augite areas; is contiguous with the augite mass and was formed from its alteration. The biotite is mainly associated with the magnetite. Although the pyroxene is abundant here, this rock answers to the augite syenyte of Irving, but has been formed from the further alteration of a basaltic diabase.

540. *East of the Brule river.*

A dark brown crystalline rock, containing lath-shaped and tabular feldspars.

The section is composed of tabular and a few lath-shaped feldspars, with augite and magnetite in a brownish groundmass. The groundmass is made up a dirty greenish brown viriditic product, derived largely from the alteration of the former basaltic base, lath-shaped or basaltic plagioclase crystals, augite grains and microlites, magnetite, secondary orthoclase and quartz, and alteration apatite, microlites, etc. The general structure of the section is porphyritic.

114. *West of Splitrock river.*

A crystalline dark gray rock. The structure of the section is ophitic and it is composed of divergent plagioclase crystals cutting the irregular augite masses. The section also contains much magnetite and olivine, which is altered along its edges and fissures to a yellowish brown serpentine. The feldspars are clear, showing brilliant polarization, while the augite is pale brown and contains much disseminated magnetite dust. The magnetite has, in places, a rectangular and oblique grating structure.

115. *West of Splitrock river.*

Is a dark, coarsely crystalline rock, composed of feldspar, pyroxene and magnetite. The section shows a mass of divergent, lath-shaped plagioclase, with a little apparent orthoclase, and with the interstitial portions filled with brownish fissured augite, olivine, magnetite, and secondary products. In this rock many of the original minerals remain clear or are but slightly altered. Of the silicates the augite has apparently suffered the least, being changed into a viriditic product at a few points only. The feldspar is altered and stained along the fissures and not infrequently changed in places to viridite. The olivine is in part clear but much of it shows the usual alteration to brownish and greenish serpentine along the borders and fissures.

The veriditic substance appears to have been formed in part from an original base in the rock, and in part it shows a spherlitic structure, or contains numerous rod-like microlites. Colorless microlites occur in the feldspar.

The augite shows excellently well the cleavage of that mineral, but is pleochroic, yellowish brown, light brown, and dark brown; as the color varies in different portions of the same crystal plane or section when in the same position, it is probable that the pleochroism is due to alteration which has affected the state of the iron, more in one portion of the crystal than in another.

115 A. *West of Splitrock river.*

A gray crystalline rock, composed principally of feldspar, containing some dark silicates.

The section is composed chiefly of feldspar, mainly plagioclase, with some yellowish and brownish augite, magnetite, greenish brown pseudormorphs, apparently after olivine, and grayish brown ones after augite.

639. *One mile east of Silver creek.*

A dark grayish brown crystalline rock. The section is composed of plagioclase, augite, olivine, magnetite, viridite, apatite, etc.

The olivine in part is fissured, with the fissures bordered by a

dark or yellowish brown serpentine, leaving clear interstitial olivine grains. Other olivine crystals are entirely altered to serpentine. The section shows much fibrous viriditic material, of a dark green color, and arranged in patches containing numerous spherulites of the viridite. This viriditic alteration is largely associated with the augite and would appear to arise from the alteration of that mineral and the original basaltic base. A little altered globulitic base yet remains inclosed in the feldspars. Some of the augite shows the cleavage of diallage.

291. *Extremity of Pigeon point.*

A gray crystalline rock with predominating feldspar.

Section is porphyritic containing tabular feldspars (plagioclase) in a matrix of plagioclase (lath-shaped), augite in irregular masses, olivine grains, magnetite, biotite, viridite, etc. The augite is somewhat pleochroic, and the olivine more or less altered, having a clear yellowish centre and a fibrous altered border, when the alteration has not affected the entire crystal. Some altered globulitic glass is to be seen in the feldspars. The biotite is a secondary product.

258. *Mt. Josephine.*

A gray compact and somewhat coarsely crystalline rock with predominating feldspar.

The section has its chief portion composed of a matted mass of feldspar crystals (plagioclase), somewhat kaolinized, holding much olivine in pale yellowish grains, and augite in very subordinate quantities, with pyrite and magnetite. The olivine is only slightly altered, as a rule, to a greenish serpentine, while the augite in some places shows the secondary diallage cleavage.

503. *St Louis river near Knife falls.*

A brownish gray medium grained crystalline rock, weathering to a yellowish brown.

The section is composed of lath-shaped plagioclase crystals, divergent, and holding in the interstices augite, olivine, magnetite, and secondary spherulitic viridite, quartz, biotite, serpentine, etc.

The augite has in part crystallized about the olivine as a centre; it is somewhat pleochroic, partially altered to biotite, and often cloudy from disseminated magnetite dust.

The olivine has largely been altered to a dark green serpentine with much precipitated magnetite. The greenish and brownish biotite is abundant as a product of alteration of the augite, the crystals of the latter showing various stages in the processs of this change. This alteration begins at the central augite core and passes in the same continuous mass through the greenish biotite into the perfect brownish biotite.

Secondary quartz occurs, both in irregular patches and in the graphic or eozoön form with cloudy feldspathic material. In connection with the quartz are long microlites.

297. *English rapids.*

A gray crystalline rock of medium texture but compact.

The section is similar to that of the preceding, No. 503. The augite, in places, shows the secondary diallage cleavage imperfectly, while the olivine is but little altered, both minerals containing numerous magnetite grains. Considerable secondary biotite occurs bordering the magnetite. The olivine affords the nuclei for the augite to crystallize about.

261. *Hills of Grand portage.*

A Grayish brown rock, weathering to a rusty brown. Medium grained and granular

Section composed of irregular masses of augite holding olivine and magnetite, and dissected by lath-shaped divergent plagioclase crystals. The olivine is abundant and is more or less altered to yellowish and brownish yellow serpentine. Considerable green viridite and some biotite formed from it occur in the section. The augite, as well as the olivine, often contains much magnetite in disseminated grains, while the former shows the secondary diallage cleavage in places.

53. *East Duluth.*

This is microscopically a dark gray compact crystalline rock, showing lath-shaped feldspars. Microscopically the section is seen to be composed of a brownish augite, feldspar, olivine, magnetite, apatite, and various secondary products. The augite

shows the *ophitic* structure first described by M. Michel Lévy,* and later by Professor Pumpelly under the name of "lustre-mottlings."† Attention has further been called to this structure by Professors A. Geikie,‡ R. D. Irving§ and J. W. Judd.|| This structure consists of a large irregular area or various areas all belonging to the same augite or diallage individual and cut by lath-shaped divergent feldspars. In one form or another this structure is very common in the diabases, and usually is the form of crystallization standing next to the granitic, in its coarseness of texture, or one step nearer the fine grained basalts. Many of the preceeding described rocks show the ophitic structure more or less perfectly, but not so well as this section. The olivine is altered for the most part to greenish, yellowish brown, brownish yellow, and black serpentine containing secondary magnetite sometimes marking the former olivine fissures. Considerable dirty green viridite and secondary apatite occur in the section, while some secondary biotite was observed in the vicinity of the magnetite. The augite in places has the secondary cleavage of diallage.

53 B. *East Duluth.*

A dark reddish brown rock containing pinkish and gray feldspars in a dark brown groundmass.

683. *Between Little lake and Little Trout lake.*

A gray crystalline rock containing lath-shaped plagioclase crystals and in the section it is seen to be composed of lath-shaped plagioclases with a few tabular feldspars forming diverging angles with each other and cutting the yellowish brown augite, which approaches diallage in its cleavage. Some greenish altered olivine pseudsmorphs of serpentine, carrying magnetite occur, while the augite is in part replaced by hornblende, chlorite, and viridite, which alteration products occupy much of the mass of the section, whose structure otherwise is ophitic.

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* Bull. Soc. Geol. France, 1877, (3), vi, 156.

† Proc. Am. Acad., 1878, xiii, 260.

‡ Trans. Roy. Soc. Edin., 1880, xxix, 495.

§ The Copper-bearing Rocks, 1883. p. 42.

|| Quart. Jour. Geol. Soc., 1885, pp. 360, 361; 1886, p. 68.

492. *Near Knife Falls.*

296. *Partridge portage.*

298. *South Fowl lake.*

These are fine grained gray crystalline rocks, approaching closely upon the more coarsely crystalline type of the melaphyrs.

No. 492 is ophitic in structure and contains some olivine which is largely altered to a greenish or brownish serpentine. Considerable viridite also occurs. No. 296 is similar, but the olivine is abundant, and but little altered, while the feldspar has suffered considerable kaolinization. No. 298 has suffered still further alteration, the olivine being nearly obliterated, and the augite in places being altered to viridite, green and brown hornblende, and biotite. Much secondary quartz, apatite, etc., occur.

49. *Duluth.*

A dark brownish gray rock of a somewhat porphyritic texture.

The section is granitic in texture and composed of lath-shaped somewhat kaolinized feldspar, magnetite, brownish augite, greenish pseudomorphs of serpentine after olivine bearing much magnetite, apatite, viridite, pyrite, and quartz. Of these the only original minerals are the feldspar, augite, olivine, and part of the magnetite.

615. *Near Pigeon point.*

A dark gray crystalline rock. The section is composed of plagioclase, magnetite, augite, and abundant secondary products, the chief of which are viridite, chlorite, biotite, apatite, magnetite, and quartz.

The augite is reddish brown and has suffered much alteration. The least altered portions are clear, but of a brown color; those portions more highly changed are filled with the dust and needles of magnetite, the same as is usually seen in the diallage of gabbros, while the most highly altered parts are changed to viridite, chlorite, biotite, etc.

459. *Lower falls of the St. Louis river.*

A grayish brown crystalline rock, with its feldspar tinged with a ruddy hue.

The section is composed of feldspar, chiefly plagioclase, augite, magnetite, and various secondary products. While the section in places is an excellent diabase, in other parts it is an equally perfect quartz dioryte, being composed of plagioclase, quartz, magnetite, hornblende, and some biotite. Secondary quartz in the graphic or eozoön form is quite abundant in portions of the section, and the rock in places shows the groundmass of a quartz porphyry. Pseudormorphs of serpentine after olivine are not uncommon. They are filled with hematite and magnetite. Viridite and ferrite are also quite abundant in the groundmass, with plates of chlorite and biotite, apatite needles, quartz, etc.

695. *North shore of Mayhew lake.*

The section is composed of feldspar, augite, magnetite, serpentine psēudormorphs after olivine, viridite, secondary quartz, apatite, microlites, biotite, etc. The augite for the most part is of a pale, yellowish tinge, with high, refractive power, and is closely like olivine, but differs optically. On its borders it is largely altered to a grayish brown fibrous material and to biotite.

137. *Sec.* 28, *T.* 56, *R.* 7.

Is a greenish crystalline rock filled with a greenish earthy material. In its geoditic cavities it contains quartz crystals surrounded by the green earth.

The structure of the section is granitoid and composed of dark greenish brown augite, highly altered feldspars, magnetite, and as secondary products much quartz and a bright green substance. The augite closely resembles some brown hornblende, but it is only feebly pleochroic, and shows the cleavage of augite distinctly. The color and appearance is doubtless owing to a partial alteration towards hornblende. Although the feldspar is much altered and filled with micaceous scales, it shows in places the triclinic twinned polarization. The clear deep green mineral is in aggregately polarizing masses, and in radiating spherules. The extinction occurs when the fibres are parallel to the plane of vibration, while the mineral is slightly pleochroic, varying from dark green to light green and to pale yellowish; and hence is most probably delessite.

47. *Superior street, Duluth.*

A brown crystalline and somewhat porphyritic rock with its feldspars partially tinged with red. Contains pyrite.

The structure of the section is ophitic and composed of divergent feldspars cutting the irregular augite grains. Angular patches of a former interstitial basaltic groundmass are now replaced by brownish and greenish scales of chlorite, viridite, ferrite, quartz, etc. Many aggregations of greenish and brownish chlorite occur in the section, replacing augite, and some from their structure and contained magnetite are probably pseudomorphs after olivine. The feldspar is much altered, showing aggregate polarization and containing numerous grains and scales of quartz, chlorite, and other micaceous minerals.

6. *Duluth.*

A dark gray crystalline rock with lath-shaped feldspars. Some of the felpspar is tinged with red.

The section has all its silicates more or less altered to quartz, chlorite, biotite, and magnetite. The pyroxenic constituent has in most places the characters of augite, but in some parts those of diallage. The section contains numerous microlites and needles of apatite, which I consider to be of secondary origin and produced during the process of the rock alteration, as in many cases they are found inclosed entirely in the secondary quartz.

In places the section has the reddish-brown groundmass of porphyrytes, composed of ferrite, chlorite, quartz, feldspar, magnetite, etc. Chloritic pseudomorphs, apparently after olivine, are common.

638. *North side of Encampment island.*

A dark brown rock of compact crystalline texture, and somewhat dark spotted.

The section is principally composed of aggregations of lath-shaped plagioclase crystals, cutting detatched irregular patches of augite. The feldspar contains inclosed much altered globulitic base as well as minute granules, which fleck the central portions. The section contains several patches of colorless and brownish chalcedonic material, showing spherulitic polarization in places. Much viridite and chlorite was observed, particularly in the

feldspars, while a chlorite vein crosses the section, with the fibres at right angles to the walls.

200. *Fall River mine.*

Is a dark brown crystalline rock, slightly porphyritic and showing the lustre mottlings of Pumpelly in places. It has been penetrated by the secondary native copper which is wrapped around the jointed fragments of the rock. It varies much in different portions in the amount of its alteration.

The section is composed of augite cut irregularly by basaltic plagioclase and interstitially holding magnetite, olivine and secondary viridite, chlorite, quartz, etc. The section in the vicinity of part of the magnetite is stained yellow and red by ferric oxide. The olivine is mainly altered to brownish hematite, to magnetite, and to yellowish and greenish serpentine. Part of the section is ophitic in structure and part *granulitic*, as that term is used by Judd.*

200 A. *Fall River mine.*

Is described as a concretion in No. 200. In the least altered, and most coarsely crystalline portions, it is composed of pinkish divergent, lath-shaped feldspars, with interstitial dark material. Irregularly intermingled with this are dark brown to black or yellowish brown masses and streaks of decomposed and softened rock with a hardness of about 3. In the coarsely crystalline portions occur segregations of chalcedony, epidote, zeolites, etc.

The least altered portions of the sections are composed of augite, magnetite, and feldspar, with various secondary products. The augite is but little changed to viridite and is of a clear pale yellow or yellowish brown color. The feldspar, however, has suffered much, being kaolinized, and contains viridite. Along the fissures and in the patches of kaolin and ferrite occurs considerable native copper, as a secondary product, or else as an infiltration. It was not observed in connection with the augite, and but rarely near the magnetite, although one might naturally expect to find it in connection with that mineral. The copper, indeed, appears mainly in the interior of the feldspars during that stage of their alteration, in which they are brownish-gray from the disseminated kaolin with subordinate ferrite, but the copper

* Quart. Jour. Geol. Soc., 1886, pp. 68, 69.

disappears when the alteration is carried still further, as it often is, in the section. The feldspar here is largely replaced by viridite and chalcedonic patches. In the sections of the more highly altered portions of this rock, the augite is changed, for the most part, to a dirty green viridite and chlorite, which show oftentimes a spherulitic structure. In the more highly altered parts many apatite needles occur.

In the portions of the rock which are most altered the chalcedony forms beautifully polarizing radiating concretions; and the general appearance of the rock is that of granite, instead of that which it really is — an altered coarse-grained diabase.

502. *Near Knife falls.*

A grayish brown crystalline rock weathering to a rusty brown.

The section is composed of lath-shaped plagioclase crystals arranged at diverging angles and holding interstitially the uniform remains of a basaltic base, also abundant brown augite, grains and rod-like masses of magnetite, and yellowish, greenish, and brownish pseudomorphs after augite and olivine. The base has been altered into a brownish granular and fibrous mass containing numerous black and colorless microlites. Biotite and viridite are common.

253. *West of Grand Portage village.*

A grayish brown crystalline rock, whose section is composed of augite, plagioclase, magnetite, and olivine largely altered to yellowish brown serpentine. In places the groundmass has been altered to a confused mass of feldspar, quartz, viridite, ferrite, and microlites. Viridite is abundant, particularly as secondary product of the augite, and biotite and ferrite are common.

107. *Point opposite of Encampment island.*

A dark brown, somewhat spotted, slightly porphyritic rock. Considerably altered.

The section is greenish, containing dark brown spots that may possibly be olivine pseudomorphs, but which more probably indicate the beginning of a pseudo-amygdaloidal structure. The structure of the section otherwise is ophitic, and besides the augite, plagioclase, and magnetite it contains much viridite, formed

both from the alteration of the augite and of the feldspar. Apatite needles are common in the more highly altered portions of the sections.

The feldspars contain numerous patches of altered globulitic base arranged zonally as they are often seen to be in the modern basalts.

106. *Encampment island.*

A dark brown rock, showing lustre-mottlings and segregations of secondary material as well as dark spots of soft altered matter, the same as that seen in 200 A. and apparently the same as the material formed in the rocks of Eastern Mass. as the beginnings of a pseudo-amygdaloidal structure.

The section is similar to that of No. 107, although it is more altered. The augite in places has been replaced by a dirty white opaque substance that closely resembles leucoxene, especially as it is usually associated with magnetite grains. Viridite is an abundant secondary product, both of the augite and of the feldspar, while the latter is often filled with inclusions of altered globulitic base.

427. *Ely island.*

Section greenish brown and of an ophitic structure. The feldspars are chiefly plagioclase and are clear, except a certain bright green alteration product, probably delessite. Olivine is common in fissured grains, which are altered to a greater or less extent to a green, dark brown, or yellowish brown serpentine. The augite is but little changed and shows the secondary diallage cleavage in places.

116. *Between Splitrock point and Two-Harbor bay.*

A dark brown crystalline rock with dark spots of soft decomposed material.

The structure of the section is ophitic and contains plagioclase, augite, olivine, magnetite, biotite, and much deep green viridite. The viridite and yellowish brown biotite occur in the feldspar, which is more altered that the augite. The olivines have mainly been changed to dark green or dark brown masses.

797. *Taylors Falls.*

A compact, greenish gray rock with feeble mottling. Fractnre conchoidal.

The sections contain clear patches composed of a single, irregular augite individual in which lie numerous feldspars as described by Prof. Pumpelly as mentioned previously. This augite and the feldspar are not much altered, but outside of this is a confused zone of altered augite, feldspar, magnite, and olivine, with their secondary products of epidote, viridite, chlorite, mica scales, magnetite, quartz, feldspar, etc., giving rise to a granular, aggregately polarizing groundmass, in which some of the original feldspar, augite, etc., can be distinguished.

854, *Mannheim's silver mine, Duluth.*

A compact brownish green rock, showing traces of lustre mottlings. Very compact and breaking with a conchoidal fracture. The thin section is similar to 797, but it has suffered further alterations. In the section are light green spots surrounded by a darker, greenish brown groundmass. The light green spots are formed by augite individuals dissected and generally with the component parts entirely separated by the altered plagioclase and viridite. Sometimes these augite masses show in polarized light, that they are composed of two or more individuals. The groundmass is mainly composed of chlorite, viridite, epidote, feldspar, ferrite, opacite, and some pseudomorphs, apparently after olivine.

678 (?) *Near Little lake.*

This section is granitic in structure and contains much magnetite.

The augite is very largely altered to yellowish and greenish viridite and chlorite. The felhspar is kaolinized and in part altered to viriditc, while the intertestial base is replaced by viridite, chlorite, and quartz with magnetite. Microlites are common.

717, *Near Duncan lake.*

A brownish gray crystalline rock.

The section shows that the rock has been much altered. Part

of the original feldspar, augite, ahd magnetite remain intact, but much of the augite has been replaced by brownish hornblende, particnlarly along the borders and ends of the crystal. Some of this hornblende shows the well-marked prismatic amphibole cleavage. The feldspar and augite are also both altered to viridite, while secondary quartz, replacing the feldspar, is abundant. In this rock we have a diabase showing a stage approaching near to the formation of a quartz dioryte by alteration.

719. *South shore of Gunflint lake.*

A dark grayish brown crystalline rock.

The section is similar to that of the preceding No. 717, but contains secondary biotite from the alteration of the augite. The secondary quartz is abundant, and, together with the other secondary minerals, is traversed by numerous actinolite and apatite needles.

722. *Sec.* 26, *T.* 65, 3 *W.*

A fine-grained compact crystalline rock spangled with pyrite.

The section is similar to those of Nos. 716 and 719, and it still shows in polarized light its original structure of divergent feldspars with the interstitial portions of pyroxene, etc. But the section is now largely composed of secondary minerals, such as chlorite, viridite, biotite, quartz, magnetite, hornblende, etc., with kaolinized feldspar and some augite. In places it shows aggregations of secondary magnetite, with their interstitial portions filled with biotite, which is also an alteration product. These forms simulate closely the appearance of a mineral partially destroyed by the molton magma, instead of being what it actually is—a mineral (biotite, holding magnetite,) in the process of formation. The augite, when altered, leaves dirty gray cloudy grains and masses resembling leucoxene, while in the midst of some of the quartz, chlorite, viridite, etc., are to be seen dark orange red and yellow secondary granules resembling titanite. They are translucent and anisotropic. Actinolite and apatite needles are not uncommon.

260. *Near the head of Wauswaugoning bay.*

A gray crystalline rock of medium grain and with lath-shaped feldspars.

This is a highly altered diabase with a section similar to those of Nos. 717, 719 and 722.

Another section has the ophitic structure, of divergent plagioclase, dissecting augite masses, with interstitial augite, magnetite, yellowish brown altered olivines, and secondary green hornblende and viridite arising from the alteration of the augite.

590. *Bottom of Silver Islet mine.*

A greenish gray, compact crystalline rock, composed of a grayish feldspathic mass, inclosing crystals of greenish hornblende.

The section is composed of more or less altered divergent feldspar crystals, holding interstitial biotite, chlorite, viridite, quartz, titanite, etc. From the ophitic structure of the section, and the basaltic character of the feldspars, the writer has no doubt that this is an altered diabase, but the augite has been entirely changed, no trace now remaining, except in the pseudomorphous chlorite, etc. The titanite in this has so increased in size as to have its crystallographic form recognizable. It is of the usual orange yellow color, and is in aggregations of crystals. The biotite is formed on the edges of, and is continuous with the chloritic or viriditic masses, as if the biotite was formed from the development of the chlorite is material.

843. *Motley.*

A brownish gray crystalline dioritic rock.

The section is composed of plagioclase, more or less altered to kaolin, viridite and quartz, with magnetite, and augite. The augite is surrounded by green and brown hornblende, continuous with the augites, and produced by its alteration.

758. *South of Ogishkie Muncie lakes.*

A grayish green crystalline rock. In the section this diabase is seen to be much altered. Its structure is ophitic, and the augite remains in places in distinct cores, surrounded by green hornblende. Quartz, viridite, chlorite, biotite, actinolite, titanite grains, etc., occur with the hornblende as secondary products. Leucoxene occurs with the iron ore, which is arranged in dash-like bars. These bars form rectangles and rhombs with one another—one perfect rhomb measuring for its inside angles.

aproximately, 70° 30' and 109° 30'. Several other imperfect rhombs yielded on measurement about the same angle.

529. *Beaver bay.*

A dark brown crystalline rock.

The section shows that the rock is in an altered condition, much of the augite being changed to viridite and brown hornblende. Secondary quartz and microlites are abundant. The feldspar in places shows still its plagioclastic twinning, and the augite in part has the secondary diallage cleavage.

716. *Between Duncan's and Mud lake.*

A greenish gray crystalline rock, somewhat altered, microscopically, while the section shows that it is microscopically a much altered specimen. Some of the augite is distinguishable, but most of it is nearly or entirely altered to viridite and green hornblende, part of which, however, is stained brown. The feldspar is also much changed to the common dirty white kaolin-like substance, while its clear spaces are replaced by secondary quartz, orthoclase, and plagioclase. Considerable apatite, biotite. and magnetite occur.

749. *S. E.* ¼ *Sec.* 28.

A dark green crystalline rock.

The section shows the usual structure of altered diabases, and is composed of divergent, quite largely altered feldspars (plagioclase), with the interstitial altered augite, magnetite, and secondary viridite, chlorite, biotite, hornblende, etc. The magnetite is associated with leucoxene and yields on measurement the same angles as that seen in No. 758.

169. *Island No.* 2

A dark greenish gray groundmass inclosing glassy porphyritic feldspars, showing triclinic twinning.

This section is that of a highly altered diabase, with only traces of the original augites left. Besides the partially altered feldspars, it contains much secondary hornblende, biotite, viridite, quartz, and apatite.

708. *North of Mayhew lake.*

A crystalline granular dioritic rock, of a rusty gray color.

The section is similar to the preceding No. 269. The secondary hornblende is, next to the feldspar, the most common mineral in the section, and there is a well-marked quartz dioryte.

709. *South side of Loon lake.*

A dark grayish brown to black, crystalline granular dioritic rock.

This, like the preceding, is a quartz dioryte, in its section, showing in the midst of the green hornblende traces of augite cores. Biotite is also quite common.

55. *East Duluth.*

A reddish brown, varying to a dark brown, crystalline granular rock.

A section of this shows it to be a greenish, altered diabase, now forming through internal changes a quartz dioryte. The secondary quartz is very abundant. The section also contains feldspar, biotite, ferrite, chlorite, viridite, and magnetite.

593. *Silver Islet mine.*

A greenish gray diabase, composed of gray feldspar interminged with a greenish groundmass.

This, like the preceding, is now a quartz dioryte and contains some biotite.

284. *Lucille island*

A fine grained, greenish gray groundmass with inclosed porphyritic feldspars, which in places show the structure of glassy plagioclase but in other parts are cloudy and dull or milky white through alteration. The thin section shows that it is now a fine grained quartz dioryte holding porphyritic feldspar crystals partially replaced by quartz. The groundmass is composed mainly of altered feldspars and secondary quartz and hornblende.

755. *South of Ogishkie Muncie lake.*

A dark green compact rock with a conchoidal fracture. This

is a greenish rock in the section and it is now composed of lath-shaped basaltic feldspars, holding interstitial magnetite and secondary hornblende and viridite. The rock originally was a basalt. but is now altered to a dioryte.

826. *Near Taylors Falls.*

A dark green compact rock, containing much epidote. Breaks with a splintery conchoidal fracture.

The section is that of a highly altered diabase, the only portions of its original structure being the remains of the divergent feldspars and some apparent opacite pseudomorphs after olivine. The rock now is composed of granules and plates of secondary minerals like green hornblende, chlorite, viridite, epidote, quartz, feldspar, ferrite, opacite, magnetite, etc. The epidote, in pale yellowish granules, is abundant.

733. *Frogrock lake.*

A greenish compact rock with a conchoidal fracture. Traversed by veins of epidote, and its joints coated by crystals of the same.

The section shows a highly altered diabase, now changed to a dioryte, and composed, for the most part, of divergent altered feldspars, with divergent uralite crystals, interspersed with plates, needles and fibres of green hornblende, chlorite, opacite, etc. Considerable epidote was seen.

358. *West end of Long lake.*

A compact green rock filled in with much secondary quartz.

The section is composed of kaolinized or granulated altered feldspars with patches of fine scales of chlorite and mica, and with pyrite, opacite, quartz, feldspar, etc. The alteration of this, as of several of the preceding diabases, is complete, and none of the minerals now present are original, but all are the products of alteration, while the rock itself is no longer a diabase, mineralogically, but is classed under that variety of basalt as an extremely altered state of diabase, commonly called a quartz dioryte.

735. *Frogrock lake.*

A greenish gray crystalline rock composed of gray feldspar, associated with greenish silicates. It closely resembles No. 593 but is more altered.

The section is gray and of a granitic structure. It is composed gray granular altered feldspars with crystals of partially altered augite.

The augite is partly replaced by uralite, chlorite, etc. Some quartz epidote and colorless mica plates were seen.

778. *Between Duck lake and L lake.*

A crystalline granular rock composed principally of feldspar and hornblende. Its structure is dioritic.

The section is composed of feldspar (largely plagioclase), augite cores, and secondary quartz, biotite, hornblende, magnetite, and microlites. The augite cores are surrounded by and pass into both biotite and uralite. The rock is now a quartz-biotite-dioryte, but the writer has no doubt that it is simply an altered diabase to which its augite and feldspar allies it.

606. *Pigeon point.*

A gray crystalline granular granitoid or dioritic rock composed macroscopically of feldspar, biotite, and hornblende.

The section is that of a highly altered but fresh rock composed now of feldspar (partly plagioclase), quartz, biotite, hexagonal plates of menaccanite, rhombic pyroxene (hypersthene), viridite, etc. The quartz and feldspar are frequently united, giving to much of the section the graphic or eozoön structure. The hypersthene is partially altered to viridite and biotite. This rock is taken as an altered diabase containing rhombic pyroxene (noryte or hypersthenyte), which now has the characters of a biotite granite with accessory hypersthene.

403. *Vermilion lake.*

A compact dark green rock, with a somewhat schistose structure, but which the writer regards as a highly metamorphosed diabase.

The section is that of a much altered but fresh rock, compose

of greenish and yellowish hornblende, quartz, feldspar (partly plagioclase), with biotite, epidote, titanite, pyrite, and microlites. In its present condition it is best classified as a quartz-dioryte in the common nomenclature.

761. *Near Ogishkie Muncie lake.*

A fine-grained greenish rock sprinkled with pyrite, and breaking with a conchoidal fracture.

The sections show an entirely altered rock composed of greenish chlorite scales, colorless micaceous plates, and numerous granules of pyrite and magnetite. Although no absolute proof can be obtained from these sections to show the original status of the rock, yet from what the writer has seen from other localities he considers this to be a highly altered diabase, now forming a chlorite rock or compact chlorite schist.

PORODYTE.

737. *Northwest of Frogrock lake.*

A greenish gray, fine grained, schistose fragmental rock, containing a few quartz grains.

The section is grayish green and composed of fragments of old basaltic rocks (melaphyr) with some probable andesite fragments, and a few of other rocks. The basic eruptive material retains its structural characters but has its base and groundmass altered to a confused fibrous and scaly plexus of green chlorite and colorless micaceous minerals with magnetite dust. The porphyritically inclosed feldspars in the melaphyr and andesite fragments are largely altered to colorless micaceous scales, but still retain their plagioclastic characters, distinguishable in polarized light. Chlorite, in plates, is also common. Considerable quartz was observed in the rock mass and in larger grains, but it is doubtful if any of the grains are original, but are rather formed by the secretion of silica during the process of the rock alteration. Much pyrite of secondary origin and a small fragment of jasper were seen. There occurs, as an alteration pro-

duct, in the section, some microlites and radiating small bluish or brownish crystals. They are generally associated with quartz or pyrite as the nucleus for radiation, and are uniaxial negative, varying in dichroism from a greenish blue to a brownish yellow. They are here referred to tourmaline. This mineral is not given in Prof. Winchell's list of minerals found in Minnesota, published in the annual report for 1882, and no mention is made of it in the index to Irving's Copper-bearing Rocks.

750. *North side of Dyke lake.*

A greenish schistose rock, containing pebbles, fragments and grains of quartz, etc.

The sections are composed of fragments of diabase, melaphyr and quartz, with interstitial material composed originally of their debris. One of the melaphyr fragments, evidently, was nearly in a glassy state in its original condition. The non-quartzose material retains its structure largely, but beyond this it has been altered to chlorite and colorless micaceous scales. The feldspars retain their outlines but are entirely filled with the colorless mica scales, and show aggregate polarization. Pyrite, in striated cubes, is very abundant as a secondary constituent of the rock. The quartz probally came from some granitoid rock.

739. *Northeast of Ogishkie Muncie lake.*

A dark greenish, compact feldspathic groundmass with greenish material scattered irregularly through this groundmass. A few lath-shaped feldspars also occur in the groundmass.

The section is composed of rounded and irregular rock fragments with their cementing debris. So far as the character of these fragments can now be ascertained they appear to be basaltic (melaphyr) with some probably more acidic ones. The pyroxene has been entirely altered to chlorite, and the feldspar largely to chlorite and colorless micaceous scales, but the triclinic character of many of the crystals is still distinct in polarized light. Much pyrite in grains is to be seen while the groundmass is changed to chlorite and colorless micaceous scales with quartz.

738. *Northeast of Ogishkie Muncie lake.*

A gray fragmental much indurated rock, containing quartz

grains and many small pebbles. It resembles a consolidated sandstone. This belongs more properly with the schists and sandstones, but is described here on account of its connection with No. 739. The section is apparently a transition specimen between one composed of basaltic material and one composed of granitic and felsitic (quartz porphyry) debris. The major part of the section is made up of quartz, and feldspar fragments, with rounded masses of felsite (quartz-porphyry) and some fragments of argillite and melaphyr. Pyrite is common. The same alterations have taken place in melaphyr and feldspar as before described, while the felsite groundmass is diversified into a confused granular mixture of quartz, feldspar, micaceous and chlorite scales. The quartz and feldspar fragments are apparently from a granite.

381. *Northeast shore of Vermilion lake.*

A grayish green compact rock traversed by quartz veins.

The section is composed largely of debris that appears to be altered melaphyr, with a few argillite fragments, quartz, a little augite, and much secondary pyrite. The groundmass of the section has sprinkled through it numerous gray and yellowish granular masses resembling titanite in the process of formation, but none are in sufficiently advanced a stage to be determined crystallographically. The melaphyr material is altered as in the preceding porodytes. Both sections of this rock show portions of a vein made up of irregular quartz grains containing liquid inclusions with moving bubbles. Portions of the rock material are arranged in wavy parallel bands, along the vein in one section, but these bands have no relation to the quartz grains themselves but pass through them indiscriminately, without regard to the boundaries of the grains.

356. *Kawasachong falls.*

A dark green compact schistose rock.

The section is composed of greatly altered debris, apparently of diabase, with fragments resembling a fine gray altered tufa (trachytic). The section is now largely altered to chlorite, micaceous scales, quartz, and magnetite, of which the chlorite predominates, with the quartz second in amount. Notwithstanding the great alteration of the section its fragmental structure yet remains complete.

ANDESYTE.

VARIETY—PORPHYRYTE.

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751. *Mallmann's peak.*

A greenish gray porphyritic rock, having a compact greenish gray or brown base, holding porphyritic inclusions of hornblende and augite.

The section has a greenish gray groundmass, holding yellowish brown crystals of hornblende, epidote and greenish pseudomorphs of chlorite. The hornblende is of the usual foreign character in the andesitic rocks, having been attacked by the molten magma, which has torn and eaten into the hornblende, that has its edges blackened and rendered magnetic by the heating and corroding effects. Some of the hornblendes here have been broken and faulted, and blackened on the broken sides, others retain only a small portion of hornblende in the interior, while others are reduced to a heap of opacite or magnetite grains. The chloritic pseudomorphs are composed of plates and scales of chlorite with some epidote, but whether they are pseudomorphs after hornblende or augite the writer can not determine. The epidote is in small crystals and crystal aggregations of pale yellowish color, with pleochroism varying from colorless to pale yellow and to a deeper yellow. The epidote is here an alteration product, and is commonly associated with the chlorite. The groundmass is altered and is now composed of chlorite scales, partially altered augite microlites and granules, magnetite grains (disseminated throughout the entire ground-

mass), feldspar, microlites, fibrous material, etc..all replacing the usual felty base of the andesytes with its inclosed minerals. Here the augite, feldspar, and magnetite are original, and the rest secondary.

So far as the writer is aware, no other rocks belonging to the andesytes have been heretofore recognized in Minnesota, or indeed about Lake Superior, except one described by the writer in 1880, * as none of the diabase-porphyrites or quartzless-porphyries of Irving appear to belong to the andesytes, so far as can be told from his description unless it be that from Stannard's rock.

Prof. N. H. Winchell has indeed observed the peculiar character of this rock, stating in the annual report for 1881: "This rock is a peculiar porphyry. The groundmass is amorphous, and the disseminated crystals are hornblende. It is unlike anything before seen." (p. 93.)

The rock itself is an altered and old andesyte of the variety known as porphyryte or hornblende-porphyryte amongst lithologists. This andesyte, in its original condition would be called by most lithologists a hornblende andesyte. Plate X, Figs. 1 and 2, show the general characters of this rock with its porphyritic structure. The hornblende grains on the left in Fig. 1 have been faulted by the action of the magma and partially coroded. This is shown by the cleavage lines and in the upper form by a twinned band seen in polarized light. In Fig. 2 the corosion of the hornblende by the magma is shown, while the line of magnetite grains in the upper hornblende show the original outline. The lower hornblende has an interior core of the groundmass. This is not owning to the inclusion of the groundmass during the crystallization of the hornblende, but is due to the interpenetration of one of the gnawing, dissolving tongues of groundmass that had penetrated the hornblende and which has been cut off during the grinding of the section, leaving it as an apparent inclusion.

136. *Island in Frogrock lake.*

A greenish gray compact rock, having a greenish groundmass, holding altered dark green crystals.

---

*Geology of the Copper and Iron Districts of Lake Superior, 1880.

The section has a greenish groundmass holding yellowish green and greenish pseudomorphs after pyroxene and perhaps hornblende. The pseudomorphs are composed chiefly of hornblende, biotite, and epidote. One twinned crystal, apparently originally of rhombic and monclinic pyroxene, has been altered to a yellowish hornblende with the dichroism varying from pale yellow to yellowish green. This shows the cleavage of hornblende while the prismatic planes are those of pyroxene. See Plate XI, Fig. 1.

The pseudomorphs show, as a rule, regular forms, but the chlorite, hornblende, and epidote also occur in irregular masses scattered through the groundmass and are formed from the molecular aggregation of their material from the groundmass and not from any direct pseudomorphic process.

The epidote is abundant and the groundmass of this section is composed of tabular altered feldspar (largely plagioclase) in a firmer groundmass of felty material, colorless mica and chlorite scales, epidote, microlites, and grayish altered magnetite. The feldspars are mainly changed to chlorite and colorless mica scales, while the mica, in quite large plates, is associated with the epidote.

The original condition of this rock was apparently that of an andesyte of the augite-andesyte type, and in its altered condition it is now best classified as a porphyryte, or if preferable, a hornblende porphyryte or even a dioryte.

The analysis given below, made by Profs. Dodge and Sidener, of this rock, shows that chemically it is the same as an altered basalt, and hence it may be that my reading of the microscopic physical characters is incorrect, if one was to be governed by the chemical composition alone in deciding.

SiO_2	49.65
Al_2O_3	16.36
Fe_2O_3	4.39
FeO	7.19
CaO	9.18
MgO	8.00
Na_2O	2.49
K_2O	1.17
H_2O	2.39
	100.82

134. *Frogrock lake.*

A greenish compact groundmass containing porphyritic crystals of feldspar and hornblende.

The sections are pale green and are composed of greenish hornblende crystals and feldspar crystals, inclosed in a fine groundmass consisting of feldspar and green hornblende plates and needles with some epidote granules. The feldspars are largely altered to micaceous scales. The hornblendes are partly composed of uralite fibres and some of the crystals show a greenish exterior with a yellowish brown interior. In one or two cases it is reversed and the greenish portion is on the inside. Some of the hornblende crystals are made up of homogeneous hornblende material and not of uralite fibres. A nodule of secondary calcite was seen. This rock is now a dioryte, but its structure is andesitic, and the writer regards it as an altered andesyte.

Plate VI, Fig. 2, shows the structure of the larger hornblende crystals inclosed in the finer groundmass.

PORODYTE.

153. *S. W. ¼ Sec.* 14, *T.* 65, 4 *W.*

A fine grained, greenish compact, fragmental rock, indurated, with a conchoidal fracture, and closely like some of the compact diabases.

The sections are green and composed of fragments of andesyte, andesitic augites, destroyed and blackened hornblendes, and a mineral which is pleochroic varying from yellow to yellowish brown and yellowish green. Most of its sections extinguish parallel to a nicol diagonal, but not all, and it appears to answer in a great measure to the rhombic pyroxene of the andesytes partially altered to hornblende. The extinction of the clear, pale yellow augite is oblique, and this is altered only to a greenish chlorite. The feldspars are altered to the usual chloritic and micaceous scales. Some epidote and quartz fragments were seen. The andesitic base is changed to a fibrous or granular material but is not altered as much as in the preceding described andesytes. This rock apparently was once an andesitic tufa or volcanic ash, as it closely resembles the modern andesitic tufas of California.

Plate XII, Fig. 1, shows in some measure the characters of this rock, and exhibits, a little to the left of the centre, one of the partially destroyed hornblendes so common in andesitic rocks.

744. *Island in the central narrows of Oghshkie Muncie lake.*

A fine-grained greenish rock of a compact structure, and conchoidal fracture. Contains some pyrites.

The sections are grayish green and composed of altered ande-

sitic fragments. This andesyte was originally made up of tabular plagioclastic feldspars in a fine felty groundmass. The feldspars and groundmass have now been altered to an aggregation of chlorite and colorless mica scales, secondary feldspar, magnetite and pyrite. The feldspars retain their forms and sometimes traces of twinning. The colorless mica is, in this section, in larger scales than those before seen, and it possesses the cleavage and optical characters of muscovite, to which mineral it is here referred.

APPENDIX.

Since the preceding pages were sent to press (March 16, 1887) the first part of Professor Rosenbusch's valuable "Mikroskopische Physiographie massigen Gesteine," second edition, has been received. On page 269 it is stated in reference to the term saxonyte (see ante, pp. 21, 22):

"Wadsworth, desen oben citirtes Werk (Lithological studies) eine in hohem Grade vollständige und werthvolle Uebersicht der meteorischen und terrestrischen Olivingesteine giebt, bezichnet diesen Typus als Saxonit; der Name ist mit Beziehung auf den von Dathe beschriebenen Rusedorfer 'Bronzit-Olivinfels' gewählt. Da die ursprüngliche Beschreibung dieses Gesteins von Dathe selbst (L. J., 1883, II, 89.) ganz wessentlich modificirt wurde, konnte der Name Saxonit nicht adoptirt werden."

In the above statement my good friend, Professor Rosenbusch, has fallen into an error concerning the conditions under which the term saxonyte was proposed. In my "Lithological Studies," the meteoric and terrestrial peridotites were first distinctly subdivided into mineralogical classes and a *single term* proposed for each subdivision. The divisions were (1) olivine; (2) olivine and enstatite; (3) olivine, enstatite, and diallage; (4) olivine, enstatite, and augite; (5) olivine and diallage; (6) olivine and augite. (l. c. pp. 84, 85, 168, 193, 194.) Having first pointed out these divisions the first, third, fifth, and sixth were respectively named from older terms: dunyte, lherzolyte, eulysyte, and picryte; while for the second and fourth divisions there were respectively proposed the names saxonyte and buchneryte. Knowing the usual fate of mineralogical terms applied to a single mineral, if any error occurs in the description, I knowingly and purposely founded my divisions upon the mineralogical unions and independent of any single rock or locality. Therefore having made out the correctness of the mineralogical division of olivine

and enstatite rocks from my own microscopic studies, and upon other rocks than those described by Dathe, I chose from a long series of suggested terms the one which seemed to be the shortest, best, and most euphonious. The division of olivine and enstatite rocks was named in honor of the *country of Saxony*, to which country belonged the rock described by Dathe, but it was in no sense *named from Dathe's rock*, nor is the term in any degree dependent on the correctness of his description, as it was distinctly stated that the term was applied to the form of peridotite composed of olivine and enstatite. (l. c. p. 193.) Further under the term saxonyte, when first proposed, I gave the descriptions of rocks from twenty-three different localities (l. c. pp. 86-94, 125-128, 127), four at least of which were from different localities in Saxony while five figures of them were also given; and to properly destroy my term, it ought to be shown that all of my descriptions were incorrect and that there are no enstatite olivine rocks.

Since the term saxonyte had been in good use over two years before the term harzburgyte was proposed by Rosenbusch, I claim, that by all the laws of priority, usage, and right, that saxonyte is entitled to stand.

I hope to be pardoned for pointing out in this connection that the *type rock* which Rosenbusch has chosen to found his name harzburgyte upon is the "schillerfels" from Baste, Harz. This rock in nearly all the specimens studied by myself* is not an enstatite-olivine rock, but an enstatite-diallage-olivine one and therefore a true lherzolyte as is the case with a number of others placed by him under the name harzburgyte, hence by his own reasoning this latter term could not be adopted, even if saxonyte had not already occupied the field.

* Lithological Studies, 1884, pp. 133, 134, plate VIII, figures 1, 2, 5.

INDEX.

ERRATA.

Page 9, nineteenth line from bottom, omit certain before terminology.
Page 18, twentieth line from top, for Jannentaz read Jannetaz.
Page 24, twentieth line from top,, for serpentinou- read serpentinous.
Page 30, seventh line from top, for apprehcaos read approaches.
Page 44, last line, for analysis read analyses.
•Page 47, thirteenth line from top; for syenyte granite read syenyte, granite.
Page 47, eighth line from bottom, for nephelitic read nepheline.
Page 51, second line from bottom, insert 1 after Fig.
Page 53, last footnote, for Arm read Ann.
Page 55, thirteenth line from top, insert than the between crystalline and latter.
Page 56, second line from top, substitute a comma for the semicolon.
Page 59, second line from bottom, for noryite read noryte.
Page 60, thirteenth and fourteenth lines from top, for protposed read proposed.
Page 60, sixth line from bottom, for serpentinezation read serpentinization.
Page 61, ninth and tenth lines from top, for formatation read formation.
Page 61, eleventh line from top, for homogenious read homogeneous.
Page 64, seventh line from top, for exists read exist.
Page 66, nineteenth line from top, for (ante——, page 00) read (ante, page 58).
Page 70, twelfth line from bottom, for sphyrulitic read spherulitic.
Page 71, thirteenth line from top, for pyroxine read pyroxene.
Page 78, seventeenth line from bottom, for changed to diallage read changed diallage.
Page 80, fourth line from top, for (ante, page 00) read (ante, pages 55–57).
Page 82, eleventh line from bottom, for analy es read analysis.
Page 88, fifteenth and sixteenth lines from top, for periphyries read peripheries.
Page 95, sixteenth line from top, for olivive read olivine.
Page 97, seventh line from bottom, for co read compared.
Page 99, sixth line from top, for alteraation read alteration.
Page 99, fourteenth line from bottom, for angite read augite.
Page 101, third line from top, for palagionite read palagonite.
Page 101, fourth line from bottom, for *See.* read *Sec.*
Page 104, fourteenth line from top, for veriditic read viriditic.
Page 104, fifteenth line from top, for spherlitic read spherulitic.
Page 106, fourth line from bottom, for microscopically read macroscopically.
Page 109, fourth and fifth lines from top, for quartz-magnetite, read quartz, magnetite.
Page 114, eighth line from top, for magnite read magnetite.
Page 114, seventh line from bottom, for felhspar read feldspar.
Page 114, sixth line from bottom, for viridite read viridite.
Page 115, first line on top, for ahd, read and.
Page 116, sixteenth line from bottom, for chlorite is material, read chloritic material.
Page 124, eigthteenth line from bottom, for chlorlte read chlorite.
Page 127, second line from bottom, for Plate VI, read Plate XI,.

EXPLANATIONS TO PLATES.

PLATE I.

Fig. 1. *Serpentine*. Page 29.

The figure shows pale yellowish irregular masses of serpentine containing magnetite grains. The yellowish serpentine patches indicate the position of some of the olivine grains, which have been altered to serpentine. The yellowish serpentine masses are surrounded by bands of lighter or colorless serpentine and by irregular lines of magnetite granules. Magnetite in aggregations of grains or in crystalline masses is also shown in the figure.

Fig. 2. *Gabbro* (*altered*). Pages 58, 65, 69, 71.

In the upper left-hand portion is represented a diallage crystal. The diallage in its upper portion, not shown in the figure, is comparatively unaltered, but the lower portion is much changed and filled with magnetite as an alteration product, which is also arranged as a fringe, on the end of the crystal, the same as iron filings are on the pole of a bar magnet. The pyroxene passes into chloritic material, and the chief portion of the figure is composed of radiating chlorite fibres with quartz and much secondary magnetite — the whole forming a chlorite schist.

Fig. 1

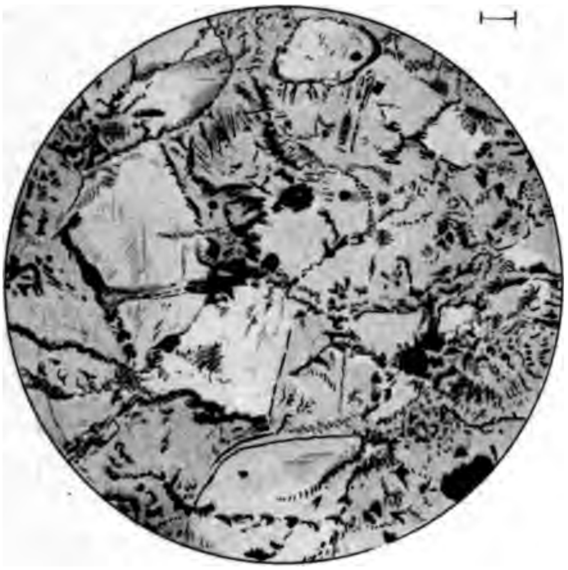

Fig. 2.

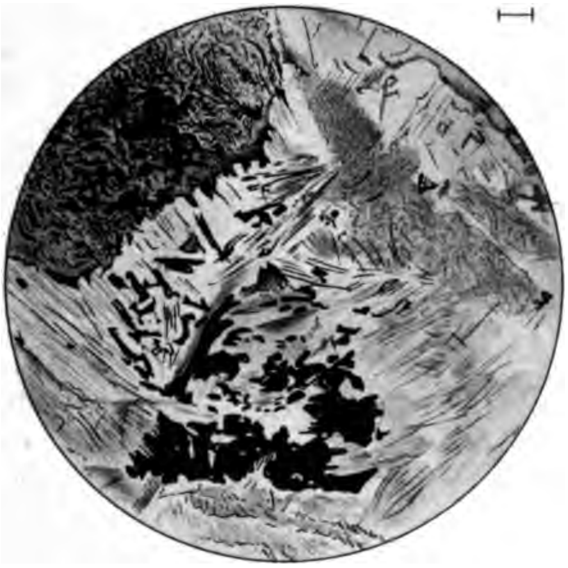

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PLATE II.

Fig. 1. *Gabbro (noryte).* Pages 59, 70.

The lower portion of the figure represents an augitic looking enstatite traversed by fissures along which a fibrous alteration or cleavage structure is formed parallel to the plane of extinction. The upper portion shows the plagioclastic feldspar cutting the enstatite, and is an earlier crystallization.

Fig. 2. *Gabbro, bearing enstatite.* Pages 59, 91.

This figure is formed by brownish irregular diallage masses cut by the colorless plagioclase, and holding rounded grains of enstatite rendered cloudy by bands of magnetite dust arranged along the cleavage lines.

Fig. 1.

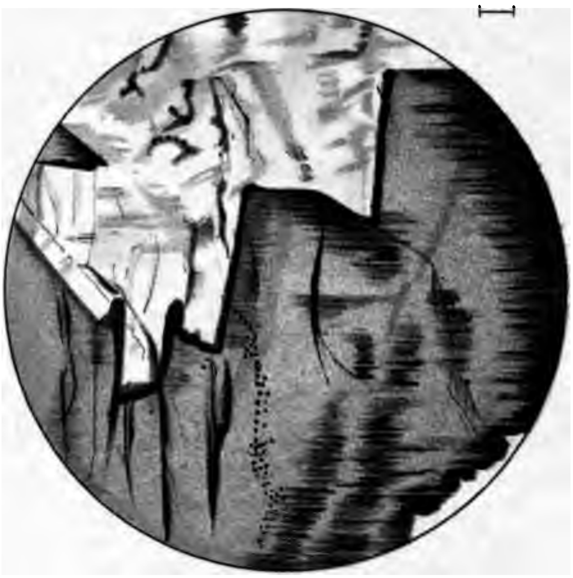

Fig. 2.

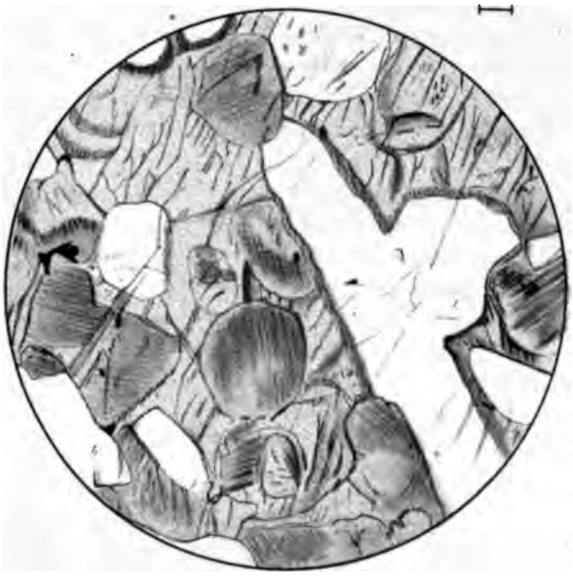

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PLATE III.

Fig. 1. *Gabbro (olivine-noryte).* Pages 59, 62, 65, 91.

The figure shows white colorless fissured plagioclase, with yellowish rounded olivines about which the enstatite has crystallized as a centre. The figure also shows patches of magnetite bordered in some cases by secondary reddish brown biotite.

Fig. 2. *Gabbro.* Pages 65, 66, 93.

This shows a crystalline section composed of pale brown diallage, colorless feldspar, yellowish altered olivine, magnetite, and reddish brown secondary biotite bordering the magnetite and diallage.

L. AND NAT. HIST. SURVEY OF MINNESOTA,

ULLETIN Nº 2 *PLATE III.*

Fig. 1.

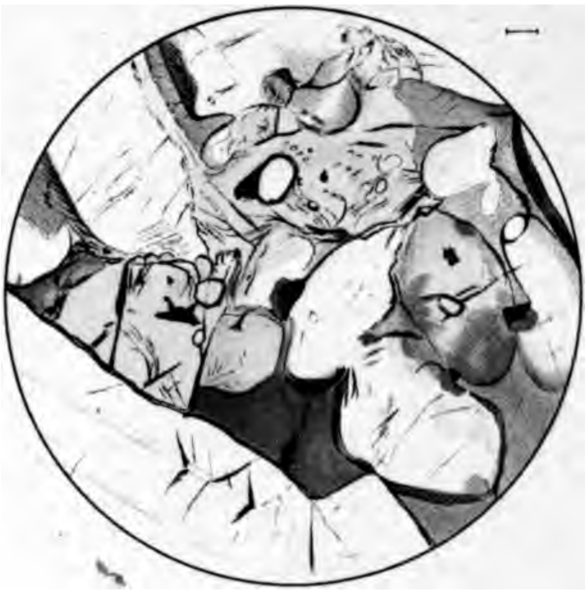

Fig. 2.

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PLATE IV.

Fig. 1. *Gabbro.* Pages 51, 66, 92.

The figure shows the fine crystalline structure, believed by the writer to be produced by the recrystallization of the materials in a rock. The chief portion of the figure is made up of rounded granules or heaps of such granules of feldspar, magnetite and diallage. On the right is shown a secondary biotite with inclusions of quartz and magnetite, while the lower portion of the figure is largely occupied by a greenish secondary hornblende.

Fig. 2. *Gabbro.* Pages 58, 66, 71.

This shows in the centre a yellowish brown diallage crystal, altered along its cleavage and fissure planes to a greenish brown biotite, which carries magnetite. Portions of the unchanged pyroxene lie between the biotite plates. The pyroxene is surrounded by partially kaolinized feldspars, which carry some magnetite and biotite scales.

GEOL. AND NAT. HIST. SURVEY OF MINNESOTA,

BULLETIN No 2 *PLATE IV.*

Fig. 1

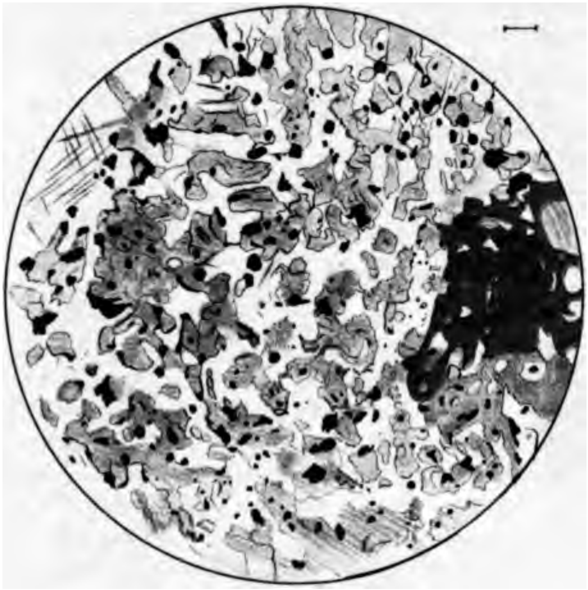

Fig. 2

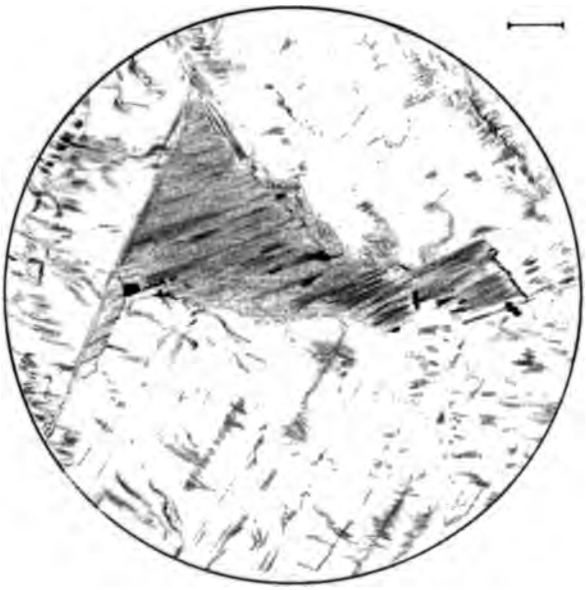

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PLATE

Fig. 1. *Gabbro* (*Forellenstein*). Pages 61, 95.

The central and upper portion of the figure is composed of colorless fissured olivine grains, traversed by a few bands of greenish serpentine lying between the olivine. Forming the base of the figure is colorless plagioclase.

Fig. 2. *Gabbro* (*Forellenstein*). Pages 61, 95.

This is from the same section as Fig. 1, and shows the alteration of the olivine to a brownish serpentine. The serpentine forms the usual network traversing the olivine fissures, leaving colorless grains of unaltered olivine in the meshes of the serpentine net. A band of feldspar is shown in the lower portion of the figure.

Fig. 1.

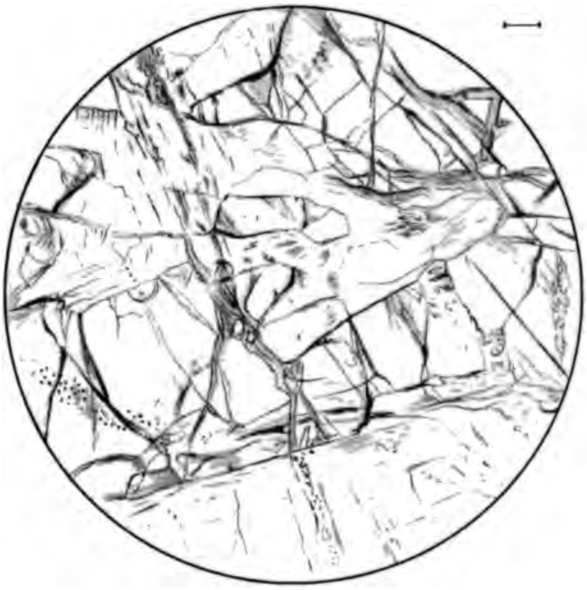

Fig. 2.

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PLATE VI.

Fig. 1. *Gabbro bearing magnetite.* Pages 65, 89.

The magnetite which occupies the principal portion of the figure is in irregular rounded grains surrounded by a brown biotite, and a clear feebly polarizing greenish substance of unknown character, but probably an early stage in the formation of biotite. The biotite is supposed by the writer to be the result of alteration and a reaction between the magnetite and the feldspar which forms the lower portion of the figure outside of the biotite border.

Fig. 2. *Gabbro.* Pages 57, 77.

This represents an imperfect spherulitic structure of believed secondary origin in the rock. It has, as the nucleus, a crystal of plagioclase with an envelope of diallage, the intermediate portion being composed of a confused radiated mass of altered rock material — ferrite, fibrous matter, viridite, kaolin, magnetite, quartz, etc. The figure also shows clear colorless patches of quartz holding microlites and some magnetite. Much magnetite in larger masses is shown in the figure. The diallage, although clear in places, for the most part has a secondary radiated structure, produced by alteration. It is this structure which gives the schillerization or micaceous character to the rock.

GEOL. AND NAT. HIST. SURVEY OF MINNESOTA.

BULLETIN Nº 2

PLATE VI

Fig. 1.

Fig. 2.

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PLATE VII.

Fig. 1. *Gabbro showing augite alteration.* Pages 57, 80.

This is a crystal of augite with its cleavage running from the bottom to the top of the figure. The crystal is partially altered to a diàllage and viridite which passes into a brownish hornblende on the right and left of the figure. The cleavage and fibrous structure of the diallage and viridite is at right angles to the augite cleavage which is obliterated by it, while the hornblende cleavage corresponds to that of the augite. None of these secondary products agree in orientation with the augite from which they are derived, but the detached areas of hornblende are optically parts of the same crystal. Many magnetite grains exist in the altered portion of the augite.

Fig. 2. *Gabbro showing diallage alteration.* Pages 58, 61, 68, 81.

The central portion of the figure is a diallage core containing a plate of secondary reddish brown biotite. This diallage core as the first step in the alteration is surrounded by viridite which penetrates along the cracks of the diallage. As the second stage in the alteration the viridite passes into hornblende which forms the altered exterior portion of the diallage. Surrounding the hornblende comes the altered rock mass now composed of quartz, which contains microlites, and magnetite, and brownish altered feldspathic material.

Fig. 1.

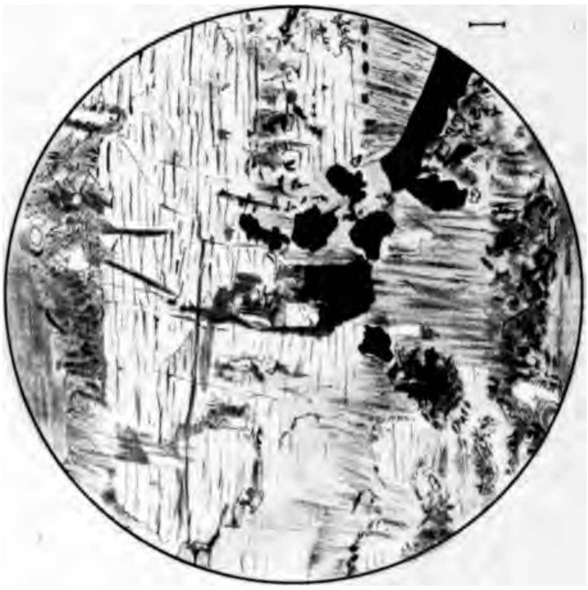

Fig. 2.

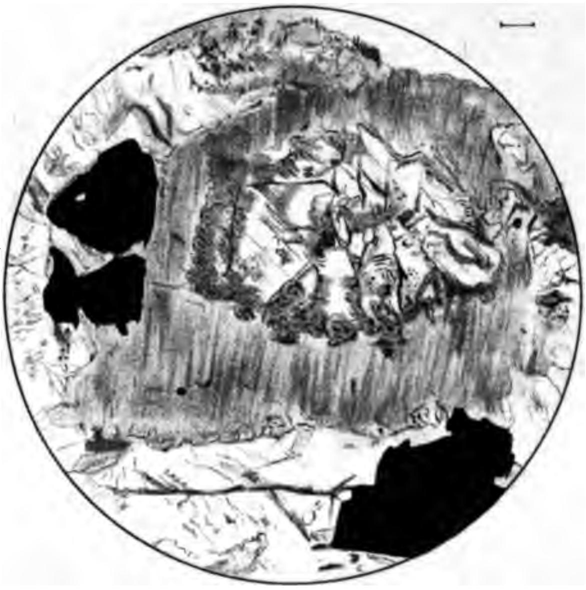

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PLATE VIII.

Fig. 1. *Gabbro showing alteration of diallage into green and brown hornblende and biotite.* Pages 58, 66, 85.

The left central portion is formed by a partially altered diallage core containing greenish and yellowish plates. The core is surrounded by a green hornblende formed from the diallage, while exteriorly the green hornblende passes into brown hornblende showing its prismatic cleavage; and also into biotite containing magnetite which has separated out during the alteration. Epidote as an alteration product occurs in the upper portion of the figure, while rounded secondary grains of quartz are seen in the hornblende. The surrounding material is feldspar and secondary quartz.

Fig. 2. *Gabbro altered to quartz diorite, showing quartz pseudomorphous aftèr plagioclase.* Pages 53, 68, 88.

The upper portion of the figure is occupied by quartz grains holding kaolinized material derived from altered feldspars, while the lower central portion is composed of quartz retaining the striations of plagioclase and part of the kaolinized matter. The right and left of the figure are occupied by brown and green hornblende, and the centre by yellowish brown titanite.

Fig. 1.

Fig. 2.

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PLATE IX.

Fig. 1. *Gabbro altered to graphic granite.* Pages 68, 81.

This is from the same section as Fig. 2 of Plate VII, and shows a reddish brown ferritic mass of altered feldspathic material inclosing angular and rounded grains of secondary quartz which carry microlites and fluid cavities. The detached grains often polarize as parts of the same individual. A brownish biotite is represented in the right hand lower portion of the figure.

Fig. 2. *Gabbro altered to a biotite-hornblende granite.* Pages 68, 81.

This is a more highly altered portion of the same section shown in Fig. 1. The central portion is occupied by secondary quartz which carries microlites and fluid cavities. On the top and bottom are represented the dark brown biotites and on the right hand a brown hornblende, all of which are of secondary origin. On the lower left hand and in the upper portion of the figure is shown the brownish alteration of the feldspathic material.

Fig. 1.

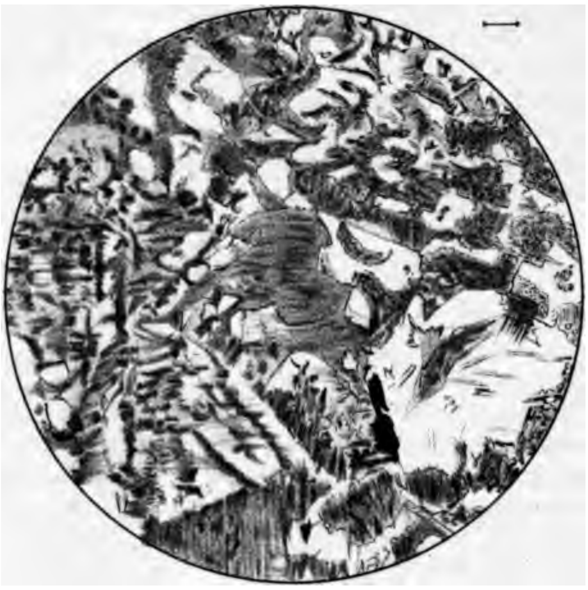

Fig. 2.

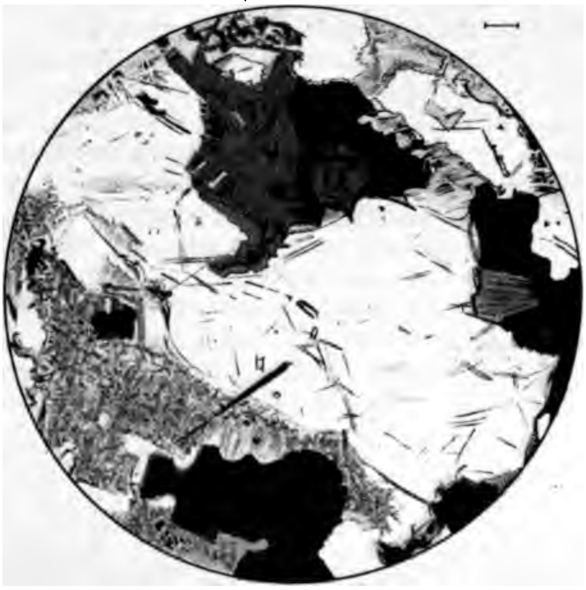

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PLATE X.

Fig. 1. *Andesyte altered to a porphyryte.* **Pages 65, 125.**

This shows the porphyritic structure of andesytes with the corroded hornblende having blackened edges. On the left are two fractured and faulted hornblendes which have been partially blackened on the broken parts since the fracture. The grayish groundmass is composed of chlorite scales, augite microlites and granules partially altered, feldspar microlites, magnetite, fibrous material, etc.

Fig. 2. *Andesyte altered to a porphyryte.* Pages 65, 125.

This figure is from the same section as Fig. 1, and shows two partially destroyed hornblendes with the interpenetrating tongues of the groundmass. The upper hornblende has its original outline on the top indicated by the band of magnetite grains. The separating groundmass has been altered to green chlorite in one spot. The lower hornblende contains a portion of one of the bays of groundmass cut off in its interior.

Fig. 1

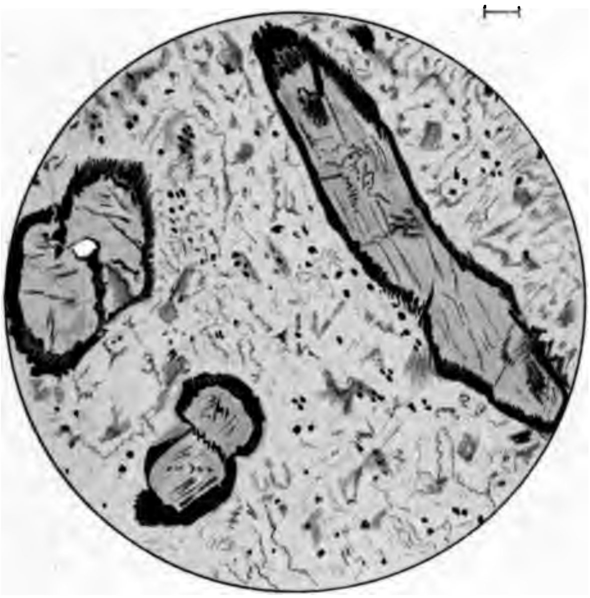

Fig. 2.

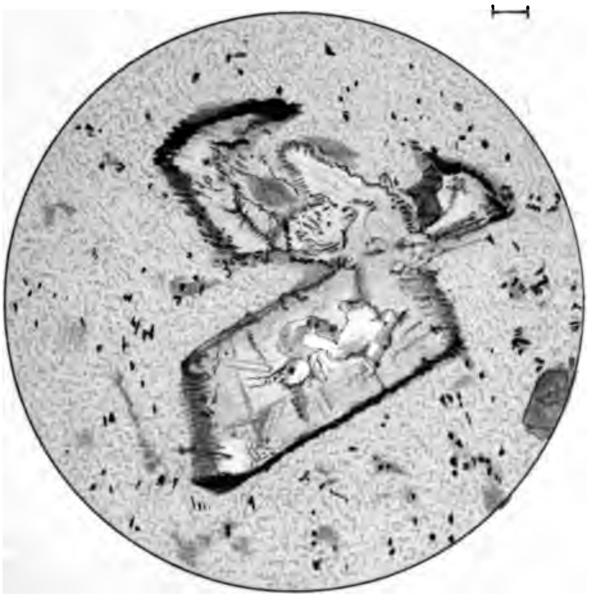

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PLATE XI.

Fig. 1. *Andesyte altered to a porphyryte.* Page 126.

This figure has its upper portion formed by a pyroxene twin, composed of twinned bands, running from right to left, of parallel and oblique extinguishing rhombic and monoclinic pyroxene. The entire crystal has been altered to a yellowish hornblende, showing the prismatic cleavage of that mineral with its dichroism, although the prismatic planes of the crystal are those of pyroxene. Below, but joined to it, is a yellowish green secondary hornblende, a crystal of which partially shows on the right. Below the first hornblende are greenish plates of chlorite and yellowish grains of epidote. The groundmass is composed of chlorite, magnetite, hornblende, etc.

Fig. 2. *Andesyte altered to a dioryte.* Page 127.

The figure shows some porphyritic secondary hornblendes containing magnetite and apatite, and surrounded by a groundmass of feldspar, hornblende, magnetite, and epidote.

Fig. 1.

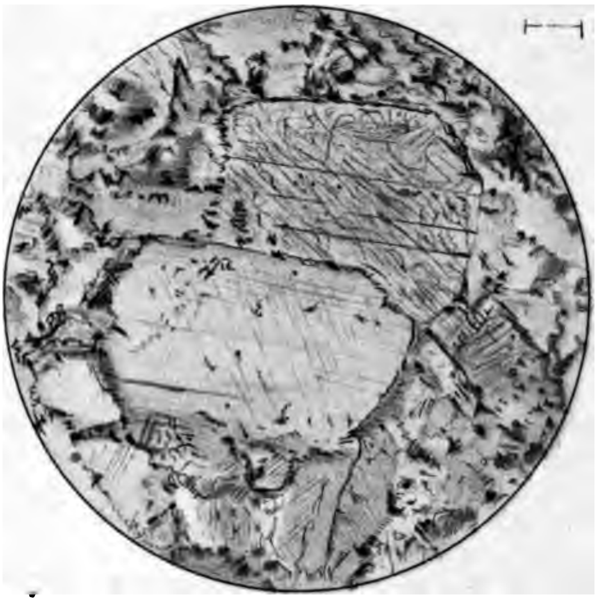
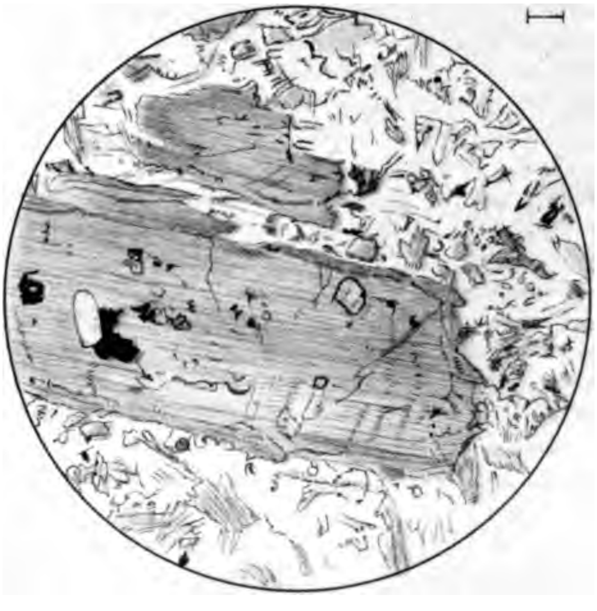


Fig. 2.



Ulrich del

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PLATE XII.

Fig. 1. *Andesyte, Porodyte.* Page 128.

This figure is of a porodyte composed of andesitic fragments, andesitic pyroxenes, partially destroyed and blackened hornblendes. and a pleochroic altered pyroxene, secondary chlorite and epidote, magnetite, and quartz fragments. The pyroxenes are partially altered to chlorite and partially to augite. To the right of the centre is shown one of the partially destroyed hornblendes with its border of magnetite.

Fig. 2. *Gabbro showing alteration of olivine.* Page 93.

The figure shows three partially altered olivines inclosed by colorless feldspar and brownish diallage. The olivine is partially divided into rectangular interspaces by two cleavages, whose lines are bordered by fine magnetite plates and needles. The alteration usually proceeds along these lines but sometimes irregularly occupies the entire portion of the olivine. The diallage shows in places its fine parallel cleavage and disseminated magnetite dust.

Fig. 1

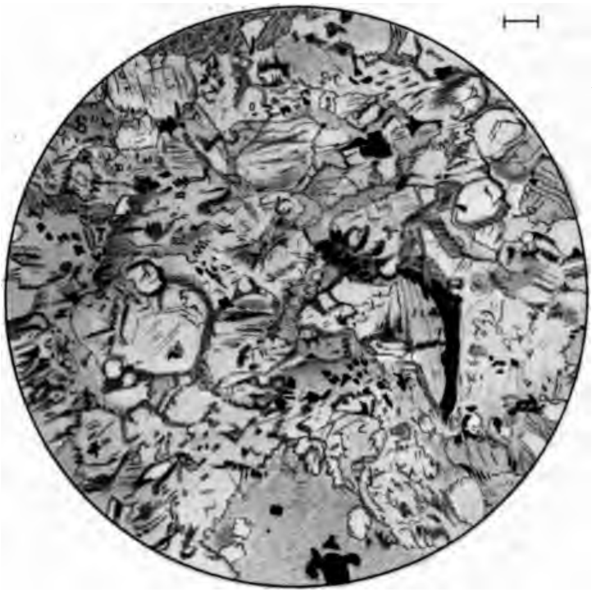

Fig. 2.

E. O. Ulrich, del.

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From

GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

N. H. WINCHELL, STATE GEOLOGIST.

BULLETIN No. 3.

REPORT

ON

BOTANICAL WORK IN MINNESOTA

FOR THE YEAR 1886.

BY J. C. ARTHUR.

ASSISTED BY MR. WARREN UPHAM, PROF. L. H. BAILEY, JR., MR. E. W. D. HOLWAY, AND OTHERS.

DISTRIBUTED OCTOBER 1, 1887.

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CONTENTS.

NARRATIVE.

The admirable collection of information on the flowering plants and vascular cryptogams, which Mr. Upham embodied in his *Catalogue of the Flora of Minnesota*, published in 1884, made available essentially all that was at that time procurable regarding the Minnesota flora, with the exception of a comparatively small amount pertaining to the lower cryptogams. Mr. Upham has brought this catalogue up to date in a supplement included in the present report.

Were botanical science stable and mature instead of changeable and growing, and could one always rely upon the determination of plants made by various observers, it would be only necessary to add to this excellent beginning such additional names as might be reported from time to time, until all the plants of the state had been enumerated, when a final revision would afford a complete flora. But such conditions do not exist, and the only satisfactory method of overcoming the sources of error accompanying the alternative, especially when the work extends through a number of years, as proposed for the Minnesota survey, is to provide a substantial basis in the form of a suitable herbarium, so that in the final enumeration a critical and comparative study of material actually in hand may serve to point out former mistakes, and enable the whole to be revised according to the latest developments of the science.

In more formally opening up the botanical work of the survey it is proposed, in accordance with these views, to emphasize at first two mutually supplementary features, the preservation of a herbarium to serve as a basis for study, and the systematic exploration of the less known parts of the state; at the same time data will be gathered, as far as possible, upon all questions of interest connected with the state flora, which will be embodied in reports as occasion requires. It is not intended to interrupt the general enumeration of plants already referred to, a part of the survey originated and prosecuted by Mr. Upham, with the co-operation of many local collectors, including several specially enthusiastic students of field botany.

The locality selected for exploration for the season of 1886 was Vermilion lake and vicinity, a region lying between the north shore of lake Superior and the International Boundry. The botanical party reached Vermilion lake July 17th, and went into

camp with the geologists already on the spot, near the village of Tower. The endeavor had been to form a small party of specialists, who were adepts at collecting plants in general, and also able to exert unusual powers of observation toward certain groups, and thus insure more important results than could be hoped for from the ordinary collector. The survey was fortunate in securing the assistance of Professor L. H. Bailey, Jr., of the Agricultural College of Michigan, well known for his critical study of the difficult genus Carex, and of Mr. E. W. D. Holway, of Decorah, Iowa, an acute observer, and especially interested in the pyrenomycetous fungi and the slime moulds. These two and the writer, with the necessary assistants, spent nearly two weeks in botanical exploration of the region already indicated.

The camp was situated at the southern end of Vermilion lake, at about 48° north latitude, and daily excursions were made within a radius of some half a dozen miles from camp. On the twenty-third of the month the point was visited where the Iron Range railroad crosses the head waters of the St. Louis river, a distance southward of about thirty miles, and all plants gathered upon that excursion are marked accordingly. On the twenty-fourth Professor Bailey, with an assistant and an Indian guide, started on a five days' trip to the British boundary at Hunter's island. Collections were made at intermediate points, given in the catalogue as Mud river, Mud lake, Burntside lake, Long lake, Fall lake, and Basswood lake. Collections were also made, although not large ones, at Duluth and Two Harbors (Agate bay), on the north shore of lake Superior, both in going and coming.

The vegetation of this region appeared ample enough when looked at casually, but a systematic search showed a discouraging paucity of species, doubtless aggravated at the time of our stay by the rather severe drought which was prevailing. The lower plants were especially meagre, and none more so than the pileated fungi. Although but a few days were occupied in this exploration, yet so thorough was the search, that it is believed a large proportion of the flowering plants were secured and are included in the following list, some of them being necessarily gathered in fruit or only in leaf, with a fair showing also of the less conspicuous part of the flora, the mosses, liverworts, fungi and algæ, including many microscopic plants.

The region has only been inhabited by Indians and hunters till about three years ago, when the opening of iron mines near the southern shore of Vermilion lake, and the construction of a

railway from that point to the north shore of lake Superior for the transportation of ore, brought in many miners, shop-keepers and adventurers, and has built up the village of Tower to about a thousand inhabitants. The summer season is so short and uncertain that almost the only crop which can be safely grown is that of potatoes. Owing to the recent and limited settlement, and to the great restriction of agricultural operations, the introduced weeds of the region are necessarily few; careful attention was given to their collection, and the result is shown in the general list. It is worth mentioning that the introduced and cultivated plants were accompanied by their usual fungous parasites—abundance of Peronospora occurred upon Chenopodium album, and of Cystopus upon Amarantus retroflexus, while the small patches of very dwarf Indian corn bore quite as much Puccinia as usually prevails in a more congenial climate.

Other features of the flora of the region are mentioned by Professor Bailey in the following article.

SKETCH OF THE FLORA OF VERMILION LAKE AND VICINITY.

BY L. H. BAILEY, JR.

In some respects the flora of this region is anomalous. In most of its features it differs little from that of central Michigan six degrees to the southward. This southern cast to the flora finds a ready explanation, however, in the fact that Vermilion lake is separated from the cooling influences of lake Superior by a degree of primeval forest. It is probably not so much the character of the winters as that of the summers which influences the distribution of plants in these latitudes. The snow must afford great protection to all vegetation at this place, and the summers, although short, are warm and the atmosphere is dry. All herbs of a more southern range find ample time to reach maturity, and the ligneous vegetation simply makes a smaller growth. This latter statement is confirmed by the small size of nearly all forest trees. Large sawing timber is not common. In an apparently primeval pine forest, we found few trees above eight or ten inches in diameter, and one measuring some six or seven inches was about a hundred years old. There are almost no distinctively northern or sub-boreal plants in the flora. The most conspicuous ones are Rosa acicularis, Alnus viridis, Sparganium simplex var. fluitans, Salix balsamifera, Lycopodium

annotinum var. pungens, Mertensia paniculata, Betula glandulosa, Vaccinium vitis-idæa and Carex vaginata. Even of these, Betula glandulosa and Vaccinium vitis-idæa were found on the St. Louis river nearly thirty miles south of Vermilion lake and more directly within the influence of lake Superior; and Alnus viridis was not observed south of Long lake, some miles northward, if we except its occurrence on the cliffs of lake Superior at Agate bay.

One of the most striking features of this flora is its monotony. Although the expedition has good reason to believe that it collected four-fifths of the flowering plants and vascular cryptogams common to the region, the collection from lake Superior to the International Boundary, did not much exceed 100 species. The flora of a similar area six degrees southwards would comprise from 1,000 to 1,200 species. Here is an illustration of the law that species decrease with the increase of latitude. I took pains to count the number of species growing upon given areas. Upon an area similar to that which would give from thirty to fifty species at Lansing, Mich., I counted from a dozen to twenty species. One of these areas, some four or more square rods, comprised the following:

Aspen — Populus tremuloides.
Birch — Betula papyrifera.
Willow — Salix rostrata.
Bush honeysuckle — Diervilla trifida.
Dogwood — Cornus stolonifera.
Bird cherry — Prunus pennsylvanica.
Epilobium — E. spicatum.
Plantain — Plantago major.
Strawberry — Fragaria virginiana, var. illinoensis.
Antennaria — A. plantaginifolia.
White clover — Trifolium repens.
Rush — Juncus tenuis.
Vetches — Lathyrus venosus and L. paluster.
Aster — A. paniculatus.
Carex — C. stipata.
Red-top — Agrostis vulgaris.
Brake — Pteris aquilina.

Moreover, most of these plants existed only as single specimens, and the character of the flora was determined by a half dozen species.

A few very rare or local plants were found, as follows:

Sparganium simplex, var. fluitans, abundant.

Nuphar advena, var. minor, known heretofore only from Litchfield, N. Y.

Potamogeton obtusifolius.

Carex houghtonii, abundant.

Monotropa hypopitys.

Juncus stygius.

Aspidium fragrans, at Basswood lake.

Littorella lacustris, at Basswood lake, just inside the International Boundary.

To these may be added Carex pinguis *n. sp.*, (C. adusta, var. glomerata), C. arctata × flexilis (C. knieskernii), and Salix lucida var. serissima, *n. var.* This variety of Salix lucida occurs at Lansing, Mich., and Ithaca, New York.

The leading forest trees of the region are:

Red pine—Pinus resinosa.

Arbor vitæ—Thuya occidentalis.

White pine—Pinus strobus.

Balsam poplar—Populus balsamifera.

Aspen—P. tremuloides, more arboreal than I have ever seen it elsewhere.

Ashes—Fraxinus americana and F. pubescens, always small.

Sugar maple—Acer saccharinum, local.

Red and silver maples—A. rubrum and A. dasycarpum, rare and small.

Burr oak—Quercus macrocarpa, local and small.

Basswood—Tilia americana, not common.

Elm—Ulmus americana, not common.

Tamarack—Larix americana and

Black spruce—Abies nigra, are common everywhere in swamps.

Paper birch—Betula papyrifera, very abundant.

Yellow birch—Betula lutea, a single tree found midway between Vermilion lake and the International Boundary; it is rather common southwards toward Agate bay.

The fruits of the region are few, and mostly poor. The best are the blueberries, chiefly Vaccinium pennsylvanicum, which grow very large and are tender and aromatic. On Hunter's island, in the International chain, fruits of this plant often measured one and two-thirds inches in circumference and the plants were wonderfully productive. The true Fragaria virginiana is occasionally met with, and its fruits are always large and

very sweet. Its var. illinoensis and F. vesca are more common, but their fruits, especially of the latter, are very poor. Various forms of the June-berry are esteemed by the Indians. The best of these forms, though not the commonest, is Amelanchier canadensis var. oligocarpa. This occurs nearer the Boundary. The small gooseberry, Ribes oxyacanthoides, occurs occasionally, but apparently is not abundant enough to furnish any considerable article of food. The dry, almost inedible fruits of a hawthorn (typical Cratægus tomentosa) are also eaten. The only members of the genus Prunus are the choke-cherry (*P. virginiana*) and the bird cherry (*P. pennsylvanica*). The fruits of the former are sometimes eaten. Red raspberries are abundant, even on Hunter's island. Black raspberries, blackberries and dewberries do not occur. Grapes are not found, and they appear to be entirely unknown to the Indians.

PLANTS COLLECTED BETWEEN LAKE SUPERIOR AND THE INTERNATIONAL BOUNARY, JULY, 1886.

BY J. C. ARTHUR, L. H. BAILEY, Jr. and E. W. D. HOLWAY.

To facilitate the work of collecting each of the three members of the party devoted his chief attention to a particular part of the flora, and numbered his specimens consecutively as gathered, prefixing his initial. Each number in this list, therefore, represents a specimen deposited in the herbarium of the survey, bearing a corresponding number. This renders it possible to verify or revise the list at any time, by the use of the original material.

The catalogue comprises some 374 genera and about twice as many species, somewhat equally divided between the flowering and flowerless plants. There are observations and critical remarks appended to many of the species, and the following new species and varieties are described:

Anthostoma flavo-viride Ellis & Holway.
Boletus americanus Peck.
Carex pinguis Bailey.
Ciboria tabacina Ellis & Holway.
Nectria perforata Ellis & Holway.
Peziza borealis Ellis & Holway.
Peziza olivatra Ellis & Holway.
Puccinia haleniæ Arthur & Holway.
Puccinia ornata Arthur & Holway.
Ramularia variegata Ellis & Holway.

Synchytrium asari Arthur & Holway.
Zygodesmus sublilacinus Ellis & Holway.
Boletus scaber Fr., var. **mutabilis** Peck.
Cosmarium speciosum Lund., var. **abbreviatum** Wolle.
Salix lucida Muhl., var. **serissima** Bailey.

Although the list does not conform to a uniform standard of classification, the arrangement of the classes and orders is approximately that which has most recently found favor with American systematists, while the genera and species are placed alphabetically in their respective groups, to facilitate reference. An index of genera will also assist in locating any particular genus.

Thanks are due to Professor Bailey and Mr. Holway for their energetic assistance in collecting, and for after work, by no means inconsiderable, in determining and arranging the material gathered. Acknowledgment is also due to the following eminent specialists for kindly determining or verifying specimens sent them, as stated at proper places in the list: Dr. Asa Gray, Dr. Sereno Watson, Prof. D. C. Eaton, Dr. W. J. Beal, Dr. John M. Coulter, Dr. Charles R. Barnes, Mr. Walter Deane, Rev. Thomas Morong, Mr. M. S. Bebb, Dr. Lucian M. Underwood, Mr. Henry Willey, Rev. Francis Wolle, Mr. J. B. Ellis, Mr. Charles H. Peck, Mr. B. W. Thomas, Dr. William Trelease and Dr. Geo. A. Rex.

PHANEROGAMIA.

RANUNCULACEÆ.

Actæa alba Bigel.— B 119, Vermilion lake.
Actæa spicata L., var. **rubra** Ait. — B 291, St. Louis river.
Anemone dichotoma L.— B 385, Mud lake.
Anemone virginiana L.— A 163, Vermilion lake.
Aquilegia canadensis L.— B 293, St. Louis river.
Coptis trifolia Salisb.— B 312, St. Louis river.
Ranunculus aquatilis L.— B 318, St. Louis river.
Ranunculus multifidus Pursh, var. **terrestris** Gr.— B 95*a*, Vermilion lake. Much reduced. (Determined by *Gray.*) B 441, Fall lake. Also much reduced, creeping in moist cool places.
Ranunculus pennsylvanicus L.f.— B 71, Vermilion lake.
Thalictrum purpurascens L.— A 68, A 158, Vermilion lake. (Determined by *Trelease.*) B 448, Mud lake. B 460, Agate bay.

NYMPHÆACEÆ.

Nuphar advena Ait., var. **minor** Morong.— B 93, Vermilion lake. (Determined by *Morong.*)

Nuphar kalmianum Ait.—B 147, B 153, Vermilion lake. (Determined by *Morong.*)
Nymphæa tuberosa Paine.—B 138, Vermilion lake.

SARRACENIACEÆ.

Sarracenia purpurea L.—B 288, St. Louis river.

PAPAVERACEÆ.

Sanguinaria canadensis L.—A 157, Vermilion lake.

FUMARIACEÆ.

Corydalis aurea Willd.—B 508, Agate bay. High bluffs of the lake.
Corydalis glauca Pursh.—B 114, Vermilion lake. B 333, St. Louis river. The latter along the railroad track; appearing as if introduced.

CRUCIFERÆ.

Brassica campestris L.—B 279, St. Louis river. Near the railroad track.
Cardamine hirsuta L.—B 405, Burntside lake.
Lepidium intermedium Gr.—B 132, Vermilion lake. B 524, Agate bay.

VIOLACEÆ.

Viola blanda Willd.—B 455, Mud lake.
Viola blanda Willd., var. **palustriformis** Gr.—B 105, Vermilion lake.
Viola blanda Willd., var. **renifolia,** Gr.—B 382, Mud lake.
Viola pubescens Ait.—B 236, Vermilion lake.
Viola striata Ait. (?)—B 378, Mud lake.

CARYOPHYLLACEÆ.

Cerastium vulgatum L. (of Gray's Manual.)—B 472, Agate bay. But one specimen seen.
Saponaria vaccaria L.—B 336, St. Louis river. Along railroad track.
Stellaria longifolia Muhl.—B 102, Vermilion lake.

HYPERICACEÆ.

Elodia campanulata Pursh.—B 55, Vermilion lake.
Hypericum canadense L.—B 428, Long lake. (Determined by *Coulter.*)

TILIACEÆ.

Tilia americana L.—B 224, B 249, Vermilion lake.

GERANIACEÆ.

Geranium carolinianum L.—B 199, Vermilion lake.
Impatiens fulva Nutt.—A 7, B 118, Vermilion lake.

CELASTRACEÆ.

Celastrus scandens L.—B 235, Vermilion lake.

RHAMNACEÆ.

Rhamnus alnifolia L'Her.— B 459, Mud lake.

SAPINDACEÆ.

Acer dasycarpum Ehrh.— B 109, Vermilion lake. Not very common.
Acer rubrum L.— B 186, Vermilion lake. Rare.
Acer saccharinum Wang.— B 225, Vermilion lake. Rare.
Acer spicatum Lam.— B 228, Vermilion lake.

ANACARDIACEÆ.

Rhus glabra L.— A 43, B 230, B 254, Vermilion lake. Flowering when a foot high.

LEGUMINOSÆ.

Lathyrus ochroleucus Hook.— A 63, B 187, Vermilion lake. The first with white flowers.
Lathyrus paluster L.— B 443, Long lake.
Lathyrus venosus Muhl.— B 186*a*, Vermilion lake.

ROSACEÆ.

Agrimonia eupatoria L.— A 164, B 191, Vermilion lake.
Amelanchier canadensis T. & G., var. **oligocarpa** T. & G.— B 407, Burntside lake. (Determined by *Watson.*)
Amelanchier canadensis T. & G., between var. rotundifolia *T. & G.* and var. botryapium *T. & G.*— B 2, B 487, Vermilion lake. (Determined by *Watson.*)
Cratægus coccinea L.— B 449, Mud lake.
Cratægus tomentosa L.— B 57, Vermilion lake. Type. (Determined by *Watson.*)
Fragaria vesca L.— B 45, Vermilion lake.
Fragaria virginiana Duch.— B 36. Vermilion lake.
Geum macrophyllum Willd.— B 253, Vermilion lake.
Geum rivale L.— A 67, Vermilion lake. B 350, Mud river.
Pirus americana DC.— B 315, St. Louis river.
Pirus sambucifolia C. & S.— B 18, B 22, Vermilion lake.
Potentilla fruticosa L.— B 495, Agate bay.
Potentilla norvegica L.— B 278, St. Louis river. Very large. B 469, Agate bay.
Potentilla palustris Scop.— B 142, Vermilion lake.
Potentilla pennsylvanica L.— B 512, Agate bay.
Potentilla tridentata Sol.— B 425, Fall lake. B 513, Agate bay.
Prunus pennsylvanica L.f.— B 169, Vermilion lake. B 351, Mud river.
Prunus virginiana L.— B 238, Vermilion lake. Not common. B 419, Long lake.
Rosa acicularis Lindl.— B 84, B 223, Vermilion lake. (Determined by *Watson.*)
Rosa arkansana Porter, var.— B 34, Vermilion lake. (Determined by *Watson.*

Rosa sayi Porter — A 81, Agate bay. (Determined by *Watson.*)

Rubus hispidus L.— B 182, Vermilion lake.

Rubus nutkanus Moc.— B 518, Vermilion lake. High banks.

Rubus strigosus Michx.— B 170, Vermilion lake. Very abundant and fruitful.

Spiræa salicifolia L.— B 95, Vermilion lake.

SAXIFRAGACEÆ.

Heuchera hispida Pursh.— B 431, Basswood lake.

Mitella nuda L.— B 88, Vermilion lake. B 388, Mud lake.

Ribes floridum L'Her.— B 77, B 108, Vermilion lake.

Ribes prostratum L'Her.— B 94, Vermilion lake. B 506, Agate bay.

Ribes rubrum L.— B 115, B 222, Vermilion lake. B 454, Mud lake.

Saxifraga pennsylvanica L.— B 329, St. Louis river.

DROSERACEÆ.

Drosera rotundifolia L.—B 136, Vermilion lake.

HALORAGEÆ.

Hippurus vulgaris L.— B 134, Vermilion lake.

Myriophyllum verticillatum L.— B 368, Mud river.

ONAGRACEÆ.

Circæa alpina L.— H 28, B 207, Vermilion lake.

Epilobium coloratum Muhl.—B 157, Vermilion lake. B 461, B 516, Agate bay.

Epilobium palustre L., var. **lineare** Gr.—B 70, Vermilion lake. B 307, B 320, St. Louis river.

Epilobium spicatum Lam.— B 9, A 153, Vermilion lake. The latter with white flowers.

Œnothera biennis L.— B 260, Vermilion lake. B 502, Agate bay.

UMBELLIFERÆ.

Cicuta maculata L.— B 251, Vermilion lake.

Sanicula marylandica L.— B 216, Vermilion lake.

Sium cicutæfolium Gmel.—B 420, Long lake.

ARALIACEÆ.

Aralia hispida Vent.— A 47, Vermilion lake. B 341, St. Louis river.

Aralia nudicaulis L.— A 41, B 227, Vermilion lake.

CORNACEÆ.

Cornus canadensis L.— A 15, B 287, Vermilion lake.

Cornus circinata L'Her.— B 234, Vermilion lake.

Cornus stolonifera Michx.—B 12, B 250, Vermilion lake. Several specimens of Cornus were collected, which are evidently to be referred to this species, although they differ from all more southern forms with which I am acquainted, in several particulars. The leaves are mostly very broad, very white beneath, and the twigs are not conspicuously reddish. The berries are uniformly white. Cornus stolonifera is apparently a very complex species.—*Bailey.*

CAPRIFOLIACEÆ.

Diervilla trifida Mœnch.— B 167, Vermilion lake.
Linnæa borealis Gron.— B 48, Vermilion lake.
Lonicera ciliata Muhl.—B 243, Vermilion lake.
Lonicera hirsuta Eaton.— B 61, B 123, Vermilion lake.
Lonicera oblongifolia Hook.—B 390, Vermilion lake.
Symphoricarpus racemosus Michx., var. **pauciflorus** Robbins.— B. 415, Burntside lake.
Viburnum opulus L.— A 174, Vermilion lake.
Viburnum pubescens Pursh.— B 62, Vermilion lake.

RUBIACEÆ.

Galium asprellum Michx.— A 72, Vermilion lake. B 356, Mud river.
Galium trifidum L.— A 10, B 73, Vermilion lake. B 275, B 297, St. Louis river.
Galium triflorum Michx.—B 44, B 210, Vermilion lake. In pine woods. B 330, St. Louis river. B 505, Agate bay.
Houstonia purpurea L., var. **longifolia** Gr.—B 474, Agate bay. Rocks.

COMPOSITÆ.

Achillea millefolium L.— B 159, Vermilion lake.
Adenocaulon bicolor Hook.—B 296, St. Louis river. Leaves only. (Determined by *Deane.*)
Anaphalis margaritacea B. & H.— B 160, Vermilion lake.
Antennaria plantaginifolia Hook.— B 218, Vermilion lake.
Aster azureus Lindl. (?)—B 507, Agate bay.
Aster longifolius Lam.—B 266, St. Louis river. (Determined by *Gray.*)
Aster macrophyllus L.— B 190, B 197, B 245, Vermilion lake. B 462, B 503, Agate bay.
Aster paniculatus Lam. (?)—B 217, Vermilion lake. Too young.
Aster ptarmicoides T. & G.—B 517, Agate bay. Rocks near the lake.
Aster sagittifolius Willd.—B 213, B 269, Vermilion lake. B 458, Mud lake. (Determined by *Gray.*)
Aster umbellatus Mill., var. **pubens** Gr.— B 198, A 66, Vermilion lake. B 337, St. Louis river. B 473, Agate bay.
Bidens beckii Torr.--B 541, Long lake.
Bidens frondosa L. (?) — B 72, Vermilion lake.
Cnicus muticus Pursh.— B 33, Vermilion lake.
Erigeron canadensis L.— B 271, St. Louis river.
Erigeron philadelphicus L.—A 65, B 285, Vermilion lake.
Erigeron strigosus Muhl.— B 161, Vermilion lake.
Eupatorium purpureum L.—A 64, Vermilion lake.
Helianthus giganteus L.— B 456, Mud lake.
Hieracium canadense Michx.—B 522, Agate bay.
Hieracium scabrum Michx.—A 166, Vermilion lake. B 308, St. Louis river.
Lactuca canadensis L.— B 196, Vermilion lake.
Lactuca leucophæa Gr.— B 457, Mud lake.

Lactuca pulchella DC.— B 4, Vermilion lake.

Petasites palmata Gr.— B 310, St. Louis river. B 501, Agate bay. Dryish ground.

Prenanthes alba L.— B 399, Mud lake. B 481, Agate bay.

Rudbeckia hirta L.— B 303, near St. Louis river; along the railroad track.

Senecio aureus L., var. **balsamitæ** T. & G.— A 50, Vermilion lake.

Solidago bicolor L.— B 387, Mud lake. (Determined by *Gray.*)

Solidago canadensis L.— B 168, Vermilion lake. B 533, Mud lake.

Solidago juncea Ait.— B 31, Vermilion lake. (Determined by *Gray.*)

Solidago lanceolata L.— B 255, Vermilion lake.

Solidago uliginosa Nutt. (?)— B 470, Agate bay. Immature.

LOBELIACEÆ.

Lobelia dortmanna L.— B 537, Burntside lake.

Lobelia kalmii L.— B 479, Agate bay. Flowers sometimes white.

CAMPANULACEÆ.

Campanula aparinoides Pursh.— B 110, Vermilion lake. B 272, B 321, St. Louis river.

Campanula rotundifolia L.— B 475, Agate bay.

ERICACEÆ.

Andromeda polifolia L.— B 280, Vermilion lake. B 295, St. Louis river.

Cassandra calyculata Don.— B 258, Vermilion lake.

Chimaphila umbellata Nutt.— B 189, Vermilion lake. B 416, Long lake.

Gaultheria procumbens L.— B 174, Vermilion lake.

Kalmia glauca Ait.— B 201, Vermilion lake.

Ledum latifolium Ait.— B 257, Vermilion lake.

Moneses uniflora Gr.— A 161, Vermilion lake. B 379, Mud lake.

Monotropa hypopitys L.— B 239, Vermilion lake.

Monotropa uniflora L.— B 156, Vermilion lake.

Pyrola chlorantha Swz.— B 173, Vermilion lake. A form with leaves very short petioled.

Pyrola rotundifolia L., var. **asarifolia** Hook.— A 42, Vermilion lake.

Pyrola secunda L.— A 14, B 78, B 166, Vermilion lake.

Vaccinium canadense Kalm.— B 141, Vermilion lake.

Vaccinium oxycoccus L.— B 332, St. Louis river.

Vaccinium pennsylvanicum Lam.— B 178, Vermilion lake. B 453, Mud lake. A form growing a foot high in crevices of rocks, and bearing good *black* berries which have a very light bloom.

Vaccinium vitis-idæa L.— B 299, St. Louis river.

PRIMULACEÆ.

Lysimachia stricta Ait.— B 11, Vermilion lake. B 463, Agate bay.

Lysimachia thyrsiflora L.— B 421, Long lake.

Primula mistassinica Michx.— B 477, Agate bay.
Steironema ciliatum Raf.—A 71, Vermilion lake.
Trientalis americana Pursh.— B 244, Vermilion lake.

OLEACEÆ.

Fraxinus pubescens Lam.— B 56, B 58, Vermilion lake.
Fraxinus sambucifolia Lam.— B 340, St. Louis river.
Fraxinus viridis Michx. f.— B 117, Vermilion lake.

APOCYNACEÆ.

Apocynum androsæmifolium L.— B 131, B 185, Vermilion lake. The latter with flowers striped with red.
Apocynum cannabinum L.— B 214, Vermilion lake.

GENTIANACEÆ.

Gentiana andrewsii Griseb.—B 355, Mud river.
Halenia deflexa Griseb.— A 51, B 192, Vermilion lake. B 191, Agate bay.
Menyanthes trifoliata L.—B 282, St. Louis river.

BORRAGINACEÆ.

Echinospermum ———?— B 248, Vermilion lake.
Mertensia paniculata Don.—B 268, Vermilion lake.

CONVOLVULACEÆ.

Cuscuta gronovii Willd.— B 180, Vermilion lake. On Epilobium spicatum.

SOLANACEÆ.

Physalis grandiflora Hook.— B 242, Vermilion lake.

SCROPHULARIACEÆ.

Castilleia coccinea Spreng.— B 302, St. Louis river. Rare.
Chelone glabra L.—B 327, St. Louis river.
Euphrasia officinalis L.—B 485, Agate bay. On rocks by the lake.
Melampyrum americanum Michx.— B 193, Vermilion lake.
Mimulus ringens L.— B 111, Vermilion lake.
Veronica scutellata L.— B 99, Vermilion lake.

LENTIBULARIACEÆ.

Pinguicula vulgaris L.— B 478, Agate bay.
Utricularia vulgaris L.— A 62, B 75, B 146, Vermilion lake.

LABIATÆ.

Brunella vulgaris L.— B 188, Vermilion lake.
Calamintha clinopodium Benth.— B 59, Vermilion lake.
Dracocephalum parviflorum Nutt.— B 53, Vermilion lake.
Lophanthus anisatus Benth.— B 49, Vermilion lake.

Mentha canadensis L. — B 3, Vermilion lake.
Scutellaria galericulata L. — B 76, Vermilion lake.
Scutellaria lateriflora L. — B 52, Vermilion lake.
Stachys aspera Michx. — B 14, Vermilion lake.

PLANTAGINACEÆ.

Littorella lacustris L. — B 437, Basswood lake.
Plantago major L. — B 258*a*, St. Louis river.

CHENOPODIACEÆ.

Chenopodium album L.—B 523, Agate bay.
Chenopodium hybridum L. — B 54, B 241, Vermilion lake.

POLYGONACEÆ.

Polygonum acre HBK. — B 370, Mud river.
Polygonum dumetorum L., var. **scandens** Gr. — B 51, Vermilion lake.
Polygonum hartwrightii Gr. — B 417, Long lake.
Polygonum muhlenbergii Wats. — B 366, Mud river.
Rumex acetosella L. — B 544, Mud lake. In a cold swamp by a trail; but one specimen found on the whole journey.
Rumex britannicus L. (*R. orbiculatus*, Gr.) — B 328, St. Louis river.
Rumex crispus L. — B 204, Vermilion lake. Near an Indian settlement.
Rumex salicifolius Weinm. — B 1, Vermilion lake.

ARISTOLOCHIACEÆ.

Asarum canadense L. — A 159, Vermilion lake.

CALLITRICHACEÆ.

Callitriche verna L. — B 367, Mud river. B 400, Mud lake.

URTICACEÆ.

Ulmus fulva Michx. — B 237, Vermilion lake.
Urtica gracilis Ait. — B 267, Vermilion lake. Rare.

MYRICACEÆ.

Comptonia asplenifolia Ait. — B 409, Burntside lake.
Myrica gale L. — B 13, Vermilion lake.

BETULACEÆ.

Alnus incana Willd. — B 152, Vermilion lake.
Alnus viridis DC. — B 445, Long lake. B 515, Agate bay.
Betula glandulosa Michx. — B 300, St. Louis river.
Betula lutea Michx. f. — B 552, Fall lake.

CUPULIFERÆ.

Corylus rostrata Ait. — B 229, Vermilion lake.
Ostrya virginica Willd. — B 232, Vermilion lake.
Quercus macrocarpa Michx. — B 534. Mud lake.

SALICACEÆ.

Populus balsamifera L. — B 162, Vérmilion lake. Common.

Populus tremuloides Michx. — B 158, Vermilion lake.

Salix balsamifera Bar. — B 16, B 140, Vermilion lake. B 480, Agate bay. (Determined by *Bebb.*)

Salix candida Willd. — B 360, Mud river. B 392, Mud lake. (Determined by *Bebb.*)

Salix humilis Muhl. — B 130, B 221, B 286, Vermilion lake. B 408, Burntside lake. (Determined by *Bebb.*)

Salix lucida Muhl. — B 358, Mud river. (Determined by *Bebb.*)

Salix lucida Muhl., var. **serissima** Bailey (*n. var.*). Differs from the species in fruiting very late. It occurs at Lansing, Mich., where its fruit matures in September, assuming a bright red color in the sun. It is one of the most ornamental of the willows. B 357, Mud river; in fruit.

Salix myrtilloides L. — B 317, St. Louis river. (Determined by *Bebb.*)

Salix myrtilloides L., var. **pedicellaris** Carey. — B 137, Vermilion lake. (Determined by *Bebb.*)

Salix petiolaris Smith. — B 359, Mud river. (Determined by *Bebb.*)

Salix petiolaris Smith, var. **gracilis** And. — B 143, Vermilion lake. B 361, Mud river. (Determined by *Bebb.*)

Salix petiolaris × **candida**. — B 362, B 363, B 364, Mud river. (Determined by *Bebb.*)

Salix rostrata Rich. — B 212, B 284, Vermilion lake. Growing fifteen feet high. B 334, St. Louis river. (Determined by *Bebb.*)

Salix ———? — B 365, Mud river.

ORCHIDACEÆ.

Corallorhiza innata R. Br. — B 89, B 247, Vermilion lake.

Corallorhiza multiflora Nutt. — A 48, Vermilion lake.

Goodyera repens R. Br. — H 29, B 177, Vermilion lake. B 304, St. Louis river. B 373, Mud lake.

Habenaria dilatata Gr. — B 290, B 324, St. Louis river.

Habenaria hookeri Torr. — B 194, Vermilion lake.

Habenaria hyperborea R. Br. — A 18, B 43, Vermilion lake. B 384, Mud lake.

Habenaria obtusata Rich. — A 160, Vermilion lake. B 380, Mud lake.

Habenaria orbiculata Torr. — H 31, Vermilion lake. B 377, Mud lake. B 560, St. Louis river.

Habenaria psycodes Gr. — B 429, Fall lake.

Orchis rotundifolia Pursh. — B 433, Basswood lake.

Spiranthes cernua Rich. — B 354, Mud river. B 444, Long lake. B 559, Vermilion lake.

Spiranthes gracilis Bigel. — B 15, B 181, Vermilion lake.

IRIDACEÆ.

Iris versicolor L. — B 220, Vermilion lake.

Sisyrinchium mucronatum Michx. — B 435, Basswood lake. B 493 Agate bay.

LILIACEÆ.

Clintonia borealis Raf.— A 46, B 120, Vermilion lake.
Lilium philadelphicum L.—B 386, Mud lake.
Maianthemum canadense Desf.— B 246, Vermilion lake.
Smilacina trifolia Desf.—B 289, St. Louis river.
Streptopus roseus Michx.—B 208, Vermilion lake.
Trillium erectum L., var. **declinatum** Gr.—A 103, B 231 milion lake.
Uvularia grandiflora Smith.—B 223, Vermilion lake.

JUNCACEÆ.

Juncus articulatus L.—B 322, St. Louis river. B 374, Mud lak 483, Agate bay.
Juncus canadensis J. Gay.— B 276, Vermilion lake.
Juncus effusus L.—B 520, Agate bay.
Juncus filiformis L.—B 17, Vermilion lake.
Juncus pelocarpus E. Meyer.—B 438, Basswood lake.
Juncus stygius L.— B 314, St. Louis river. Rare.
Juncus tenuis Willd.— B 125, Vermilion lake.
Juncus ———? —B 468, B 486, Agate bay.
Luzula pilosa Willd.—B 383, B 401, Mud lake.

TYPHACEÆ.

Sparganium simplex Huds., var. **fluitans** Gr.—B 85, Vermilior
Sparganium simplex Huds., var. **nuttallii** Gr.; nearly.— I Vermilion lake.

ARACEÆ.

Acorus calamus L.— B 50, Vermilion lake.
Arisæma triphyllum Torr.—A 156, Vermilion lake.
Calla palustris L.— B 98, Vermilion lake.

ALISMACEÆ.

Sagittaria heterophylla Pursh.— B 542, Long lake. (Determin *Watson.*)
Sagittaria variabilis Eng.— B 154, Vermilion lake. Leaves floati
Sagittaria variabilis Eng , var. **angustifolia** Eng.—B 151, Ver lake.

NAIADACEÆ.

Naias flexilis R. & S.—B 389, Mud lake.
Potamogeton claytonii Tuck.— B 410, Burntside lake. B 540, B 550, Long lake. (Determined by *Morong.*)
Potamogeton gramineus L.— B 46, Vermilion lake. (Deter by *Morong.*)
Potamogeton gramineus L., var. **maximus** Morong.—B 69 milion lake. B 403 in part, Burntside lake. (Determined by *Morong.*)
Potamogeton gramineus L., var. **elongatus** Morong.— B B 448, B 449, Long lake. (Determined by *Morong.*)

Potamogeton mucronatus Schrad.— B 369, Mud river. A slender form. (Determined by *Morong.*)

Potamogeton natans L.—B 86, Vermilion lake. B 391, Mud lake. (Determined by *Morong.*)

Potamogeton obtusifolius M. & K.—B 155, Vermilion lake. (Determined by *Morong.*)

Potamogeton pectinatus L.—B 124, Vermilion lake. (Determined by *Morong.*)

Potamogeton perfoliatus L., var. **lanceolatus** Rob.—B 47, B 149, Vermilion lake. (Determined by *Morong.*)

Potamogeton prælongus Wulf.—B 404, Burntside lake. (Determined by *Morong.*)

Potamogeton pusillus L. (?)—B 394, Mud lake. (Determined by *Morong.*)

Potamogeton pusillus L., var **tenuissimus** M. & K.—B 538, Long lake. (Determined by *Morong.*)

Potamogeton robbinsii Oakes.—B 393, Mud lake. B 442, Fall lake. The latter in fruit! (Determined by *Morong.*)

Potamogeton rufescens Schrad.—B 402, Burntside lake. B 551, Mud lake. (Determined by *Morong.*)

Potamogeton spirillus Tuck.—B 414, B 539, Long lake. (Determined by *Morong.*)

Potamogeton zosterifolius Schum.—B 403 in part, Burntside lake. B 545, Long lake. (Determined by *Morong.*)

Scheuchzeria palustris L.—B 305, St. Louis river.

Triglochin maritimum L.—B 326, St. Louis river.

ERIOCAULONACEÆ.

Eriocaulon septangulare With.—B 536, Burntside lake.

CYPERACEÆ.

Carex adusta Boott.—B 7, Vermilion lake. B 283, St. Louis river. B 558, Long lake. B 464, B 526, B 531, Agate bay.

Carex aquatilis Wahl.—B 145, Vermilion lake.

Carex arctata Boott.—B 211, Vermilion lake. B 556, Mud lake.

Carex arctata × **flexilis** Bailey.—B 554, B 555, Long lake. See *Bot. Gazette*, vol. XI, 1886, p. 328, for a description and illustration of this hybrid.

Carex arctata × **flexilis** or **arctata** × **vaginata.**—B 375, Mud lake.

Carex aurea Nutt.—H 30, Vermilion lake.

Carex buxbaumii Wahl.—B 471, Agate bay.

Carex canescens L., var. **polystachya** Boott.—B 74, B 100, Vermilion lake.

Carex crinita Lam.—B 107, Vermilion lake.

Carex deweyana Schw.—B 37, Vermilion lake.

Carex echinata Murr., var. **microstachys** B.—B 482, Agate bay.

Carex filiformis L.—B 200, Vermilion lake.

Carex flexilis Rudge.—B 557, Long lake.

Carex houghtonii Torr.— B 206, Vermilion lake. Abundant. B 509, Agate bay.

Carex intumescens Rudge.— B 68, Vermilion lake.

Carex laxiflora Lam., var. **intermedia** Boott.— B 116, Vermilion lake. B 335, St. Louis river.

Carex lenticularis Michx.— B 406, Burntside lake; in water. B 465 Agate bay.

Carex limosa L. — B 294, St. Louis river.

Carex magellanica Lam.— B 90, Vermilion lake. B 298, St. Louis river.

Carex monile Tuck.— B 274, St. Louis river. B 423, Fall lake.

Carex pauciflora Lightf.— B 203, Vermilion lake.

Carex pinguis Bailey (*n. sp.*). (*C. adusta* Boott, var. *glomerata* Bailey.) I collected this sedge in quantity in several places, and observed its habits. It appears to be specifically distinct from *C. adusta*. From that species it differs in its stiff culm, dense broad head of which some spikes, or at least the lowest one, are subtended by a short and very broad-based, nerved and pointed bract, and very plump perigynium which is nearly filled by the achenium, flat or convex and nerveless or very nearly so on the inner face, wingless or slightly margined above. It grows in dense tufts in dry soil. Slender and immature specimens strongly resemble *C. adusta*, but they are always readily distinguished by the perigynium.— B 6, Vermilion lake. B 325, St. Louis river. B 530, Agate bay.

Carex polytrichoides Muhl.— B 29, Vermilion lake. B 316, St. Louis river.

Carex retrorsa Schw.— B 67, B 101, Vermilion lake.

Carex rostrata With.— B 144, Vermilion lake.

Carex rostrata With., var. **utriculata** Bailey.— B 112, Vermilion lake.

Carex scoparia Schk.— B 8, B 60, Vermilion lake; the latter a conglomerate form. B 301, St. Louis river. B 466, B 492, Agate bay; a small form.

Carex stipata Muhl.— B 521, Agate bay.

Carex straminea Schk., var. **mirabilis** Tuck.; nearly.— B 41, Vermilion lake.

Carex tenella Schk.— B 30, Vermilion lake.

Carex tenuiflora Wahl.— B 281, St. Louis river. Slender form.

Carex tribuloides Wahl., var. **cristata** Bailey.— B 259, Vermilion lake.

Carex tribuloides Wahl., var. **reducta** Bailey.— B 35, B 92, B 184, Vermilion lake. B 418, Long lake; not quite typical. B 525, Agate bay.

Carex tribuloides Wahl., between vars. cristata and reducta.— B 270, Vermilion lake.

Carex trisperma Dew.— B 91, Vermilion lake.

Carex tuckermani Boott.— B 104, Vermilion lake.

Carex vaginata Tausch.— B 352, Mud river. B 543, Long lake.

Eleocharis acicularis R. Br.— B 150, Vermilion lake.

Eleocharis palustris R. Br.— B 19, Vermilion lake. B 535, Long lake.

Eleocharis pygmæa Torr.— B 149, Vermilion lake.

Eriophorum polystachyon L.— B 202, Vermilion lake.

Rhynchospora alba Vahl.— B 319, St. Louis river.

Scirpus cæspitosus L.—B 467, Agate bay. Growing in crevices of rocks.

Scirpus eriophorum Michx.—B 164, Vermilion lake.

Scirpus fluviatilis Gr.—B 21, Vermilion lake.

Scirpus lacustris L.—B 219, Vermilion lake.

Scirpus subterminalis Torr.—B 412, Burntside lake.

GRAMINEÆ.

The grasses determined by Dr. W. J. Beal.

Agropyrum caninum R. & S.—B 42, Vermilion lake.

Agropyrum repens L.—B 511, Agate bay.

Agropyrum violaceum Lange.—B 494, Agate bay.

Agrostis alba L.—B 127, Vermilion lake.

Agrostis scabra Willd.—B 129, Vermilion lake.

Brachyelytrum aristatum P. B.—B 397, Mud lake.

Bromus ciliatus L.—B 5, Vermilion lake.

Cinna pendula Trin.—B 323, St. Louis river.

Deschampsia cæspitosa P. B.—B 424, Fall lake.

Deyeuxia canadensis Hook—B 10, B 256, Vermilion lake. B 529, Agate bay.

Deyeuxia langsdorffii Kunth.—B 519, Agate bay.

Eatonia pennsylvanica Gr.—B 32, Vermilion lake.

Elymus virginicus L.—B 265, St. Louis river.

Festuca ovina L.—B 450, Mud lake.

Festuca ovina L., var.—B 489, Agate bay.

Glyceria arundinacea Kunth.—B 97, B 263, Vermilion lake.

Glyceria canadensis Trin.—B 264, B 273, Vermilion lake.

Glyceria fluitans R. Br.—B 20, Vermilian lake.

Glyceria nervata Trin.—B 103, Vermilion lake. B 349, Mud river.

Hierochloa borealis R. & S.—B 451, Long lake.

Hordeum jubatum L.—B 128, Vermilion lake.

Muhlenbergia mexicana Trin.—B 422, Long lake.

Phalaris arundinacea L.—B 446, Mud river.

Phalaris canariensis L.—B 528, Two Harbors; in the town.

Phleum pratense L.—B 292, St. Louis river. Scattered from the railroad.

Poa cæsia Sm., var. **strictior** Gr.—B 469, B 514, Agate bay.

Poa compressa L.—B 527, Agate bay.

Poa lævis Vasey.—B 439, Basswood lake.

Poa nemoralis L.—B 183, Vermilion lake. Along a trail in woods. B 426, Fall lake. B 434, Basswood lake.

Poa pratensis L.—B 488, Agate bay. Tall and slender form.

Poa serotina Ehrh.—B 510, Agate bay.

Trisetum subspicatum P. B., var. **molle** Gr.—B 490, Agate bay.

CONIFERÆ.

Juniperus communis L.—B 411, Burntside lake.

Picea nigra Link.—B 171, Vermilion lake.

Pinus resinosa Ait.—B 96, Vermilion lake.

Pinus strobus L.—B 240, Vermilion lake.

Taxus baccata L., var. **canadensis** Gr. — B 165, Vermilion lake.

Thuya occidentalis L. — B 83, B 133, Vermilion lake. B 381, Mud lake; seedlings.

PTERIDOPHYTA.

ISOETÆ.

Isoetes echinospora Durieu, var. **braunii** Engelm. — B 81, Vermilion lake. Submerged on stones. B 413, Long lake. (Determined by *Watson.*)

SELAGINELLEÆ.

Selaginella rupestris Spring. — A 171, Duluth. On rocks. B 447, Mud lake.

LYCOPODIACEÆ.

Lycopodium annotinum L. — A 162, Vermilion lake. B 311, St. Louis river.

Lycopodium annotinum L., var. **pungens** Desv. — B 135, Vermilion lake.

Lycopodium clavatum L. — A 31, A 98, Vermilion lake.

Lycopodium complanatum L. — A 99, Vermilion lake.

Lycopodium dendroideum Michx. — A 40, Vermilion lake.

Lycopodium lucidulum Michx. — B 309, St. Louis river.

OPHIOGLOSSACEÆ.

Botrychium virginianum Swz. — B 38, Vermilion lake.

FILICES.

Aspidium cristatum Swz. — A 155, Vermilion lake. B 353, Mud river.

Aspidium fragrans Swz. — B 430, Basswood lake. Growing on rocks.

Aspidium spinulosum Swz. — B 106, Vermilion lake. B 432, Basswood lake. B 440, Fall lake.

Aspidium spinulosum Swz., var. **intermedium** Eaton. — B 252, Vermilion lake.

Asplenium filix-fœmina Bernh. — A 152, A 163, Vermilion lake. B 339, St. Louis river. B 396, Mud lake. B 553, Fall lake; an aberrant form. (The last determined by *Eaton.*)

Onoclea sensibilis L. — A 154, Vermilion lake.

Onoclea struthiopteris Hoffm. — A 165, Vermilion lake.

Osmunda claytoniana L. — B 175, Vermilion lake.

Osmunda regalis L. — B 338, St. Louis river.

Phegopteris dryopteris Fee. — A 32, Vermilion lake. B 398, Mud lake.

Phegopteris polypodioides Fee. — B 209, Vermilion lake. B 436, Basswood lake. B 504, Agate bay.

Polypodium vulgare L. — B 176, Vermilion lake.

Pteris aquilina L. — B 215, Vermilion lake.

Woodsia ilvensis R. Br. — A 151, Duluth. B 452, Long lake. B 476, B 484, Agate bay.

EQUISETACEÆ.

Equisetum arvense L.— B 172, B 262, Vermilion lake. Common; the latter is the var. *serotinum* Meyer.

Equisetum limosum L.—B 139, Vermilion lake.

Equisetum sylvaticum L.— B 28, B 261, Vermilion lake. Common.

BRYOPHYTA.

The mosses determined by Dr. Charles R. Barnes, the liverworts by Dr. Lucian M. Underwood.

SPHAGNACEÆ.

Sphagnum acutifolium Ehrh.— A 11, A 33, A 59, A 61, A 60, Vermilion lake. The last is near var. *fuscum* Schimper.

Sphagnum cymbifolium Ehrh.— A 13, Vermilion lake.

Sphagnum squarrosum Pers.— A 12, A 36, Vermilion lake.

BRYACEÆ.

Atrichum undulatum Beauv.— A 96, Vermilion lake. Not common.

Aulacomnium palustre Schwag.—B 25, Vermilion lake.

Bryum argenteum L.—B 500, Agate bay,

Bryum bimum Schreb.— A 5 in part (?), B 23 (?), Vermilion lake. B 427, Fall lake.

Bryum intermedium Brid.— A 2, Vermilion lake.

Ceratodon purpureus Brid.—B 80, Vermilion lake, B 499, Agate bay.

Climacium dendroides W. & M.— A 21, Vermilion lake.

Dicranum drummondii Muller.— B 24, Vermilion lake.

Dicranum flagellare Hedw.— A 95, Vermilion lake.

Dicranum scoparium Hedw.— B 346, St. Louis river.

Dicranum undulatum Turn.— A 102, Vermilion lake. B 306, St. Louis river.

Fontinalis lescurii Sull., var. **gracilescens** Sull.— A 30, B 82, Vermilion lake.

Funaria hygrometrica Sibth.— B 121, Vermilion lake. A 146, B 343, St. Louis river.

Hypnum crista-castrensis L.— A 91, Vermilion lake. A 128, B 313, St. Louis river.

Leptobryum pyriforme Schimp.— B 26, Vermilion lake. A 147 in part, B 342, St. Louis river.

Leucobryum vulgare Hampe.— A 127, St. Louis river.

Mnium affine Bland.— B 372, Mud lake.

Mnium cinclidioides Hub.— A 3, Vermilion lake. This species has not been heretofore recorded as occurring outside of New England.

Mnium cuspidatum Hedw.— A 113, A 116, Vermilion lake.

Mnium punctatum Hedw.— A 177, Vermilion lake.

Mnium serratum Laich.— A 5 in part, Vermilion lake.

Neckera oligocarpa Br. & Schr.— A 35, Vermilion lake. Beautiful fruiting specimens of this rather rare species, which is recorded only from the White mountains, Colorado and New Mexico. The plants form numerous shelf-like projections from the tree trunks.

Orthotrichum strangulatum Beauv.— A 8, A 117, Vermilion lake. The first is a form in which the capsule is not strangulate or ribbed when dry; otherwise identical with A 117, which is typical.

Philonotis fontana Brid.— B 497, B 498 (male), Agate bay.

Polytrichum commune L.— A 81, A 129, Vermilion lake. The latter varies from the type.

Polytrichum juniperinum Willd.— B 345 in part, St. Louis river.

Polytrichum piliferum Schreb.— A 143, Duluth. On exposed rocks.

Pylaisæa intricata Br. & Schr.— A 39, Vermilion lake.

Tetraphis pellucida Hedw.— A 178, A 179, Vermilion lake.

Webera nutans Hedw.— A 16, Vermilion lake.

MARCHANTIACEÆ.

Conocephalus conicus Dum.— A 100, Vermilion lake. Sterile.

Marchantia polymorpha L.— A 69, B 113, Vermilion lake. Very common.

JUNGERMANIACEÆ.

Blepharostoma trichophylla Dum.— A 126 in part, St. Louis river.

Blepharozia ciliaris Dum.— A 70, Vermilion lake.

Frullania eboracensis Got.— A 29, A 44, Vermilion lake.

Jungermania inflata Huds.— A 126 in part, St. Louis river. On rotten logs.

Jungermania schraderi Mart.— A 126 in part, St. Louis river.

Madotheca platyphylla Dum.— A 114, Vermilion lake. On tree trunks.

Pellia epiphylla Nees.— A 175, Vermilion lake. Sterile.

CARPOPHYTA.

HYMENOMYCETES.

Agaricus (Amanita) **muscarius** L. — A 135, Vermilion lake. (Determined by *Peck.*)

Agaricus (Collybia) **confluens** Pers. — A 74, A 195, Vermilion lake. (Determined by *Peck.*)

Agaricus (Inocybe) **eutheles** B. & Br. — A 185, Vermilion lake. (Determined by *Peck.*)

Agaricus (Omphalia) **campanella** Batsch. — A 55, A 75, A 173, Vermilion lake. (Determined by *Peck.*)

Agaricus (Omphalia) **gracillimus** Weinm. — A 194, Vermilion lake. (Determined by *Peck.*)

Agaricus (Pholiota) **squarrosus** Mull. (?) — A 140, Vermilion lake. Not mature. (Determined by *Peck.*)

Agaricus (Pleurotus) **sapidus** Kalchb. — A 110, Vermilion lake. A very small specimen. (Determined by *Peck.*)

Agaricus (Pluteus) **cervinus** Schæff. — A 150, Vermilion lake. (Determined by *Peck.*)

Agaricus (Pluteus) **nanus** Pers. — A 111, A 119, Vermilion lake. Determined by *Peck.*)

Boletus americanus Peck, *ined.*—A. 182, Vermilion lake. "This has generally been referred to *B. flavidus* Fr., but my more recent investigations lead me to believe it is distinct."—*Chas. H. Peck.*

Boletus granulatus L.—A. 125, Vermilion lake. (Determined by *Peck.*)

Boletus scaber Fr.—A 139, Vermilion lake. (Determined by *Peck.*)

Boletus scaber Fr., var. **mutabilis** Peck, *ined.*—A 120, Vermilion lake. "The change of color in the flesh on exposure to the air leads me to separate this as a variety; I detect no other essential difference."—*Chas. H. Peck.*

Cantharellus cibarius Fr.—A 108, Vermilion lake. (Determined by *Peck.*)

Clavaria flaccida Fr.—H 82, Vermilion lake. On rotten logs. (Determined by *Ellis.*)

Clavaria ligula Schaff.—B 373*a*, Mud lake. (Determined by *Ellis.*)

Corticium amorphum (Pers.) Wint. (*Aleurodiscus amorphus* Rabh.)—H 180, St. Louis river. On tamarack. (Determined by *Ellis.*)

Corticium corrugatum Fr. (*Hymenochæte corrugata* Berk.)—H 158, Vermilion lake.

Corticium epichlorium B. & C.—H 155, Vermilion lake. (Determined by *Ellis & Cooke.*)

Corticium giganteum Fr.—H 175, Vermilion lake. On tamarack.

Corticium ochroleucium Fr., var. **spumeum** B. & R.—H 138, Vermilion lake. On logs.

Corticium salicinum Fr.—H 42, Vermilion lake. On Salix discolor.

Cyphella fulva B. & Rav.—H 226, Vermilion lake. On dead limbs of Alnus.

Dædalea unicolor Fr.—H 201, Vermilion lake.

Favolus europæus Fr.—H 142, Vermilion lake.

Glæoporus conchoides Mont.—H 257, Vermilion lake. On logs.

Hygrophorus cantharellus Schw.—A 73, Vermilion lake. (Determined by *Peck.*)

Hydnum adustum Schw.—H 263, Vermilion lake. (Determined by *Ellis.*)

Hydnum auriscalpium L.—H 196, St. Louis river. In swamps. (Determined by *Ellis.*)

Hydnum caryophylleum B. & C.—H 252, Vermilion lake. On poplar log.

Hydnum ferruginosum Fr.—H 87, Vermilion lake. On rotten log. (Determined by *Ellis.*)

Hydnum membranaceum Bull.—H 184, Vermilion lake.

Irpex tulipifera Schw.—H 239, Vermilion lake.

Lactarius pyrogalus Fr. (?)—A 107, Vermilion lake. No note was made at the time of collection of the presence or absence of a milky juice, which necessarily leaves some doubt about the determination. (Determined by *Peck.*)

Lentinus betulina Fr.—H 132, Vermilion lake. On stumps.

Lentinus lecontei Fr.—H 106. Vermilion lake. On logs.

Lentinus lepideus Fr.—A 53, Vermilion lake. (Determined by *Peck.*)

Lentinus strigosus Schw.—A 106, A 124, Vermilion lake. (Determined by *Peck.*)

Lenzites sæpiaria Fr.—H 80, Vermilion lake. On dead Abies alba.

Lenzites sæpiaria Fr., var. **porosa** Pk.—H 73, Vermilion lake. On log of Abies. (Determined by *Ellis.*)

Marasmius ———?—H 65, Vermilion lake. In swamps. Appears to be undescribed, *fide* Ellis, but the material too scant for description.

Merulius aureus Fr.—H 204, Vermilion lake. On old log.

Odontia fimbriata Pers.—H 147, Vermilion lake. On fallen limbs.

Panus lævis B. & C.—A 141, Vermilion lake. (Determined by *Peck.*)

Phlebia merismoides Fr. —H 249, Vermilion lake. On logs. (Determined by *Ellis.*)

Phlebia spilomea B & C. —H 104, H 250, Vermilion lake. On Populus tremuloides.

Polyporus abietinus Fr. — H 79, Vermilion lake. Resupinate form. On log of fir. (Determined by *Ellis.*)

Polyporus applanatus Fr. —H 238, Vermilion lake. On logs.

Polyporus carneus Nees. —H 172, Vermilion lake. On logs; common. (Determined by *Ellis.*)

Polyporus conchatus Fr. —H 211, Vermilion lake. On logs.

Polyporus fomentarius Fr. —H 255, Vermilion lake. On birch.

Polyporus igniarius Fr. —H 237, Vermilion lake. On birch.

Polyporus loricatus Pers., var. —H 221, Vermilion lake.

Polyporus nitidus Fr. —H 203, Vermilion lake.

Polyporus perennis Fr. —H 66, Vermilion lake. On the ground.

Polyporus pergamenus Fr. —H 183, St. Louis river. On birch.

Polyporus picipes Fr. —H 220, Vermilion lake. On logs.

Polyporus pinacola Fr. —H 91, Vermilion lake. On pine logs. (Determined by *Ellis.*)

Polyporus schweinizii Fr. —A 138, St. Louis river. (Determined by *Peck.*)

Polyporus scutellatus Schw. —H 219, Vermilion lake. On Alnus.

Polyporus spissus Fr. —H 145, Vermilion lake. On birch. (Determined by *Ellis.*)

Polyporus subspadiceus Fr. — H 246, Vermilion lake.

Polyporus vaporarius Fr.—H 154, Vermilion lake. On rotten limbs. (Determined by *Ellis.*)

Polyporus varius Fr.—H 24, H 222, Vermilion lake. On fallen logs and limbs.

Polyporus velutinus Fr.—H 161, Vermilion lake. On fallen limbs.

Polyporus violaceus Fr.— H 234, Vermilion lake. On fir. (Determined by *Ellis.*)

Polyporus vulgaris Fr.— H 70, H 253, Vermilion lake. On dead Abies. (Determined by *Ellis.*)

Russula fragilis Fr.— A 183, Vermilion lake. (Determined by *Peck.*)

Schizophyllum commune Fr.— H 69, Vermilion lake. On old stumps.

Solenia poriæformis (Pers.) Wint. (*Peziza pruniata* Schw.)—H 254, Vermilion lake. On rotten log. (Determined by *Ellis.*)

Stereum radiatum Pk.—H 240, Vermilion lake. (Determined by *Ellis.*)

Stereum rugosum Fr.— H 197, Vermilion lake. On birch.

Stereum spadiceum Fr.— H 218, Vermilion lake. (Determined by *Ellis.*)

Trametes cinnabarina (Jacq.) Wint. (*Polyporus cinnabarinus* Fr.) —H 117, Vermilion lake. A 189, Agate bay.

Trametes sepium Bk.—H 72, Vermilion lake.

Trogia crispa Fr.—H 140, Vermilion lake. On dead Betula papyracea.

Typhula muscicola Fr.—H 235, Vermilion lake. On moss. (Determined by *Ellis.*)

TREMELLINEÆ.

Exidia glandulosa Fr.—H 43, Vermilion lake. On Salix discolor.

Hirneola auricula-judæ Berk.—H 185. Vermilion lake. On dead limbs.

Tremella mesenterica Fr.—H 190, St. Louis river. On tamarack.

GASTEROMYCETES.

Geaster triplex Jungh.—A 142, Vermilion lake. (Determined by *Peck.*)

Lycoperdon pyriforme Schæff.—A 104, A 136, A 193, Vermilion lake. On the ground in woods. (Determined by *Trelease.*)

Lycoperdon wrightii B. & C. (?)—A 144, Vermilion lake. An immature specimen, growing on a rotten log. (Determined by *Trelease.*)

USTILAGINEÆ.

Entyloma compositarum Farl.—H 243, Vermilion lake. On Lactuca canadensis.

UREDINEÆ.

Coleosporium sonchi-arvensis (Pers.) Lev.—H 83, H 102, H 165, H 251, Vermilion lake. II. On Aster, the first on A. umbellatus, and the second on A. corymbosus.

Melampsora epilobii (Pers.) Wint.—H 49, H 89, Vermilion lake. II. On Epilobium palustre, var. lineare, and E. coloratum. H 35, Duluth. II. On E. coloratum.

Melampsora populina (Jacq.) Wint.—H 198, Vermilion lake. II. On Populus tremuloides.

Melampsora salicis-capreæ (Pers.) Wint.—H 101, Vermilion lake. II. On Salix discolor. H 166, St. Louis river. II. On Salix myrtilloides.

Phragmidium rubi-idæi (Pers.) Wint.—H 205, Vermilion lake. II. & III. On Rubus strigosus.

Phragmidium subcorticium (Schrank.) Wint.—H 247, Vermilion lake. III. On Rosa acicularis. H 187, Vermilion lake. II. & III. On Rosa sayi. H 3, St. Louis river. II. On Rosa———.

Puccinia asteris Duby.—H 37, Duluth. On Aster macrophyllus. H 273, Agate bay. On Aster———.

Puccinia calthæ Lk.—H 96, Vermilion lake. II. On Caltha palustris.

Puccinia caricis (Schum.) Reb.—H 162, St. Louis river. III. On Carex adusta. H 217, Vermilion lake. II. & III. On C. intumescens.

Puccinia circææ Pers.—H 214, Vermilion lake. On Circæa alpina.

Puccinia flosculosorum (A. & S.) Roehl.—H 270, Agate bay. On Hieracium canadense.

Puccinia galii (Pers.) Wint.—H 94, Vermilion lake. On Galium asprellum.

Puccinia grossulariæ (Gm.) Wint.— H 213, Vermilion lake. On Ribes rubrum.

Puccinia haleniæ Arthur & Holway (*n. sp.*). III. Sori irregularly confluent in indefinite groups on the stems and upper surface of the leaves, black, polished, solid, minutely papillose, remaining covered by the epidermis or sometimes tardily naked; teleutospores linear or cuneate-linear, smooth, brown with darker apex, 42–52 by 8–9 mu., epispore thin, apex squarely or obliquely truncate, or irregularly blunt, little or not at all thickened, pedicel very short, colored.— H 100, Vermilion lake. On Halenia deflexa.

To the unaided eye this bears more resemblance to some pyrenomycetous fungi than to the rusts.

Puccinia maydis Carr.— H 136, Vermilion lake. II. On Zea mays.

Puccinia menthæ Pers.— H 236, Vermilion lake. II. On Mentha canadensis.

Puccinia mesomegala B. & C.— H 18, Vermilion lake. On Clintonia borealis.

Puccinia nardosmii E. & E.— H 232, Vermilion lake. On Petasites palmata.

Puccinia ornata Arthur & Holway (*n. sp.*) III. Sori hypophyllous, papilliform, prominent, circinately clustered on bright reddish-purple spots 5-10 mm. in diameter, often forming a wart-like cluster at the centre, chocolate-brown; teleutospores elongated oval or oblong, smooth, uniformly brown, somewhat constricted at the septum, 33-50 by 15-22 mu, epispore rather thin, apex obtuse or rounded, slightly or not at all thickened, base rounded or somewhat narrowed, pedicel thick, slightly colored, once to twice the length of the spore.— H 223, Vermilion lake. On Rumex britannica L. (*R. orbiculatus* Gray.)

This belongs to the section Leptopuccinia; the germinating spores give a whitened or moldy appearance to the central sori of each cluster.

Puccinia phragmitis (Schum.) Korn.— H 137, Vermilion lake. II. & III. On Phragmites communis.

Puccinia polygoni-amphibii Pers.— H. 48, H. 50, Vermilion lake. On Polygonum muhlenbergii.

Puccinia porphyrogenita Curt. — H 108, Vermilion lake. On Cornus canadensis.

Puccinia tanaceti DC.— H 133, Vermilion lake. II. On Helianthus giganteus.

Puccinia tiarellæ B. & C.— H 62. Vermilion lake. On Mitella nuda.

Puccinia tomipara Trel.— H 12, Vermilion lake. II. On Bromus ciliatus.

Puccinia violæ (Schum.) Wint.— H 131, Vermilion lake. II. & III. On Viola blanda.

Triphragmium clavellosum Berk.— H 17, Vermilion lake. On Aralia nudicaulis.

Uromyces orobi (Pers.) Wint.— H 25, Vermilion lake. II. On Vicia americana.

Uromyces polygoni (Pers.) Fckl.— H 5, H 113, H 116, Vermilion lake. II. & III. On Polygonum aviculare.

Uromyces trifolii (A. & S.) Wint.— H 34, Duluth. I. & II. On Trifolium repens.

Isolated imperfect forms.

Æcidium compositarum Mart.— H 141, Vermilion lake. On Solidago.
Æcidium lycopi Ger.— H 216, Vermilion lake. On Lycopus virginicus.
Æcidium porosum Pk.— H 14, Vermilion lake. On Vicia americana.
Æcidium ranunculacearum DC.— H 212, Vermilion lake. On Ranunculus abortivus.
Æcidium thalictri Grev.—H 210, Vermilion lake. On Thalictrum purpurascens.
Cæoma agrimoniæ Schw.—H 209, Vermilion lake. On Agrimonia eupatoria.
Peridermium abietinum (A. & S.) Thum., var. **decolorans** Thum. — H 93, Vermilion lake. On Picea nigra.
Peridermium balsameum Pk.— H 208, Vermilion lake. On Abies balsamea.
Uredo pyrolæ (Gm.) Wint.— H 27, Vermilion lake. On Pyrola secunda.

LICHENES.

Determined by Mr. Henry Willey, except Nos. B 24a, B 39, B 40, and B 195, which were determined by Prof. F. Le Roy Sargent.

Alectoria jubata (L.) Tuck.— A 168, St. Louis river.
Buellia parasema (Ach.) Kbr.— A 87, Vermilion lake. On birch.
Cetraria lacunosa Ach.—A 181, Vermilion lake.
Cladonia cristatella Tuck.— A 123, Vermilion lake.
Cladonia gracilis (L.) Nyl., var. **elongata** Fr.— A 122, Vermilion lake.
Cladonia gracilis (L.) Nyl., var. **verticillata** Fr.— A 17, A 19, B 40, Vermilion lake.
Cladonia rangiferina (L.) Hoffm.—B 24*a*, A 121, Vermilion lake.
Collema cyrtaspis Tuck.— A 45, Vermilion lake. On standing tree trunks.
Collema nigrescens (Huds.) Ach.— A 27, A 97, Vermilion lake.
Endocarpon miniatum (L.) Schr., var. **aquaticum** Schr.— A 132, St. Louis river. On partially submerged rocks.
Evernia prunastri (L.) Ach.—A 115, Vermilion lake.
Graphis scripta (L.) Ach. — A 39, A 169, Vermilion lake.
Lecanora subfusca (L.) Ach., var. **distans** Ach. — A 79, Vermilion lake.
Lecidea enteroleuca Ach. — A 23, A 170, Vermilion lake.
Leptogium myochroum (Ehr., Schar.) Tuck., var. **saturnium** Schar. — A 37, Vermilion lake. On dead tree trunks.
Parmelia caperata (L.) Ach. — A 25, Vermilion lake.
Parmelia olivacea (L.) Ach. — A 80, Vermilion lake.
Parmelia physodes (L.) Ach. — A 28, Vermilion lake.
Parmelia tiliacea (Hoffm.) Flk. — A 26, Vermilion lake.
Peltigera aphthosa (L.) Hoffm. — B 39, Vermilion lake. (Determined by *Sargent.*)
Peltigera canina (L.) Hoffm. — A 6, Vermilion lake. On the ground.
Peltigera polydactyla (Neck.) Hoffm. — A 131, St. Louis river. On the ground.

Physcia cæsia (Hoffm.) Nyl.—A 171, Vermilion lake. On rocks.

Physcia stellaris (L.)—A 24, Vermilion lake.

Placodium aurantiacum (Lightf.) Nag. & Hepp.—A 145, Vermilion lake. On poplar.

Placodium cerinum (Hedw.) Nag. & Hepp.—A 93, Vermilion lake. On poplar.

Placodium elegans (Lk.) DC.—A 171, Vermilion lake.

Pyrenula ——?—A 105, Vermilion lake. On poplar.

Sticta amplissima (Scop.) Mass.—A 38, Vermilion lake.

Sticta pulmonaria (L.) Ach.—A 34, Vermilion lake.

Theloschistes chrysophthalmus (L.) Norm.—A 85, Vermilion lake.

Theloschistes concolor (Dicks.) Tuck.—A 94, Vermilion lake. On living Populus tremuloides.

Usnea barbata (L.) Fr., var. **cavernosa** Tuck.—A 167 in part, St. Louis river.

Usnea barbata (L.) Fr., var. **dasypoga** Fr.—A 167 in part, St. Louis river.

Usnea barbata (L.) Fr., var. **florida** Fr.—A 53, Vermilion lake. Sterile.

Usnea barbata (L.) Fr., var. **plicata** Fr.—B 195, Vermilion lake. (Determined by *Sargent.*)

PYRENOMYCETES.

Anthostoma flavo-viride Ellis & Holway (*n. sp.*) Stroma effused, thin, extending for two or more inches in length and one-half inch or more in width, covered at first with a thin coat of greenish-yellow, short, matted hyphæ, producing small (1-1½ mu), subglobose, subhyaline conidia, but finally bare and black. Perithecia membranaceous, black, globose (½ mm.), sunk in the scarcely altered substance of the wood, contracted above into a narrow neck which penetrates the thin stroma with a black papilliform ostiolum. Asci (spore bearing part) 75 by 6-7 mu, or including the slender base 120 mu long. Sporidia uniseriate, narrow elliptical, continuous, nearly hyaline at first, becoming dark, 10-12 by 4-4½ mu. The stroma is limited in the substance of the wood by a dark circumscribing line.—H 266, Vermilion lake. On decaying wood of Populus tremuloides.

Chilonectria cucurbitula (Curr.) Sacc.—H 178, Vermilion lake. On Abies. H 182, St. Louis river. On tamarack.

Claviceps ——— ?—A 134, St. Louis river. On Deyeuxia canadensis.

Daldinia concentrica (Bolt.) C. & De N.—H 256, Vermilion lake. On dead Alnus.

Diatrype stigma Fr.—H 120, H 112, Vermilion lake. The first on Alnus, the second on birch.

Diatrype tocciæana De Not.—H 55, Vermilion lake. On Alnus. (Determined by *Ellis.*)

Diatrypella betulina Pk.—H 39, H 90, Vermilion lake. The first on Betula papyracea, the second on B. pumila.

Eutypella cerviculata (Fr.) Sacc.—H 75, H 76, Vermilion lake. The first on Alnus incana, the second on Betula papyracea.

Gnomoniella coryli (Batsch.) Sacc.—H 139, Vermilion lake. On Corylus rostrata.

Hypocrea citrina (Pers.) Fr.—H 146, H 245, Vermilion lake. The first on Exidia, the second on Polyporus. (The latter determined by *Ellis.*)

Hypocrea richardsoni Berk. & Mont.—H 45, Vermilion lake. On poplar.

Hypomyces aurantius (Pers.) Fckl.—H 115, Vermilion lake. On Polyporus. (Determined by *Ellis.*)

Hypomyces lactifluorum (Schw.) Tul.—H 143, Vermilion lake. On Lactarius.

Hypomyces rosellus Tul.—H 230, Vermilion lake. On Polyporus loricatus. (Determined by *Ellis.*)

Hypoxylon commutatum Nitsch.—H 144, Vermilion lake. On Alnus. (Determined by *Ellis.*)

Hypoxylon commutatum Nitsch., var. **holwayanum** Sacc.—H 248, Vermilion lake. On Alnus.

Hypoxylon ferrugineum Fr.—H 193, St. Louis river. On old logs. (Determined by *Ellis.*)

Hypoxylon fuscum (Pers.) Fr.—H 119, H 151, Vermilion lake. On Alnus incana.

Hypoxylon morsei B. & C.—H 99 Vermilion lake. On Alnus.

Hypoxylon multiforme Fr.—H 262, Vermilion lake. On Betula papyracea.

Hypoxylon serpens (Pers.) Fr.—H 265, Vermilion lake. On poplar log. (Determined by *Ellis.*)

Hypoxylon transversum Schw.—H 41, Vermilion lake. On Betula papyracea.

Hysterium angustatum A. & S.—H 177, Vermilion lake. On Betula.

Hysterographium gerardii (C. &. P.) Sacc.—H 200, Vermilion lake. On old board. (Determined by *Ellis.*)

Hysterographium fraxini De Not.—H 224, Vermilion lake. On Fraxinus.

Lasiosphæria hirsuta (Fr.) C. & De N.—H 40, Vermilion lake. On rotten log.

Lasiosphæria ovina (Pers.) C. &. De N.—H 148, Vermilion lake. On rotten wood.

Lophodermium maculare (Fr.) De N.—H 74, Vermilion lake. On fallen leaves of Ledum. (Determined by *Ellis.*)

Lophodermium pinastri (Schrad.) Chev.—H 107, Vermilion lake. On leaves of Pinus resinosus.

Melanconis alni Tul.—H 268, Vermilion lake. On Alnus incana.

Melanconis stilbostoma (Fr.) Tul.—H 63, Vermilion lake. On Betula pumila.

Nectria episphæria Fr.—H 111, Vermilion lake. On Diatrype stigma.

Nectria perforata Ellis & Holway. (*n. sp.*) Perithecia gregarious and subconfluent, $\frac{1}{8}$–$\frac{1}{4}$ mm. in diameter, subtuberculose roughened and pruinose furfuraceous, pale at first, becoming orange-red, depressed-globose, ostiolum papilliform, collapsing when dry so that the perithecia appear broadly perforated above. Asci clavate-cylindrical, 75 by 7–8 mu, without paraphyses. Sporidia obliquely uniseriate, elliptical or subovate, smooth, uniseptate, hyaline or with a faint tinge of rose-color.—H 260, Vermilion lake. On a decaying Agaricus of the section Pleurotus.

Plowrightia morbosa (Schw.) Sacc.—H 163, Vermilion lake. On Prunus pennsylvanicus.

Valsa nivea Fr.—H 103, Vermilion lake. On Populus tremuloides.

Valsa salicina Fr.—H 77, Vermilion lake. On Salix discolor. (Determined by *Ellis.*)

Isolated imperfect forms.

Bactridium ellisii Berk.—H 109, Vermilion lake. On rotten wood.

Cercospora leptosperma Pk.—H 152, Vermilion lake. On Aralia nudicaulis.

Didymaria ungeri Cda. (*Ramularia didyma* Ung.)—H 88, Vermilion lake. On Ranunculus pennsylvanicus.

Fusarium berenice (B. & C.) Sacc.—H 67, Vermilion lake. On Abies balsamea.

Glomerularia corni Pk.—H 2, Vermilion lake. On Cornus canadensis.

Melanconium betulinum Schm. & Kze.—H 97, Vermilion lake. On Betula papyracea. H 85, Vermilion lake. On Betula pumila.

Melanconium bicolor Nees.—H 95, Vermilion lake. On Betula papyracea.

Oidium radiosum Lib.—H 272, Agate bay. On Populus balsamifera.

Ramularia tulasnei Sacc.—H 206, Vermilion lake. On Fragaria virginiana.

Ramularia urticae Ces.—H 164, Vermilion lake. On Urtica gracilis.

Ramularia variabilis Fckl.—H 9, Duluth. On Verbascum thapsus.

Ramularia variegata Ellis & Holway (*n. sp.*) Spots amphigenous, large, indefinite, ½-1 cm. in diameter, above reticulately spotted with white or brown, less distinctly so below. Hyphæ amphigenous, but mostly hypophyllous, fasciculate, hyaline, simple, toothed above, 15-25 by 4 mu. Conidia oblong-cylindrical, hyaline, uniseptate, and often constricted at the septum, 20-35 by 3½-4½ mu.—H 233, Vermilion lake. On living leaves of Petasites palmata.

Septoria astragali Desm.—H 60, Vermilion lake. On Lathyrus ochroleucus.

Septoria coptidis B. & C.—H 231, Vermilion lake. On Coptis trifoliata.

Septoria corylina Pk.—H 207, Vermilion lake. On Corylus rostrata.

Septoria mimuli E. & K.—H 105, Vermilion lake. On Mimulus ringens.

Septoria polygonorum Desm.—H 153, Vermilion lake. On Polygonum cilinode.

Septoria rubi West., var. **pallida** E. & H.—H 47, Vermilion lake. On Rubus hispidus.

Stilbum tomentosum Schr.—H 114, Vermilion lake. On some myxogaster.

Trichothecium roseum (Pers.) Lk.—H 181, St. Louis river. On tamarack.

Zygodesmus sublilacinus Ellis & Holway (*n. sp.*). Forms a continuous, thin, felt-like stratum of a dirty lilac color on rotton wood (of some deciduous tree) and on birch bark. Margin slightly paler. Main hyphæ coarse, much branched, the tips of the branches enlarged and bearing the coarsely echinulate, rather irregularly shaped spores, about 7 mu in diameter,

on distinct spicular sporophores.—H 188, Vermilion lake. The same thing has been found at Newfield, N. J., on bark of pine log.

HELVELLACEÆ.

Cenangium cerasi Fr.—H 157, Vermilion lake. On Prunus pennsylvanica.

Chlorosplenium versiforme Fr.—H 267, Vermilion lake. On old stumps.

Ciboria tabacina Ellis & Holway (*n. sp.*). Stem slender, almost filiform, slightly enlarged above, ½-1½ cm. long, and like the outside of the perithecium, yellowish tobacco-brown. Perithecia cupulate-patelliform, 1½-2½ mm. in diameter, subrugulose beneath, margin entire and even, only slightly incurved. Disk slate-color, concave. Asci cylindrical, 100-115 by 9-11 mu. Paraphyses stout, yellowish, gradually but only slightly thickened above. Sporidia uniseriate, elliptical, mostly with a single large nucleus, yellowish-hyaline, 9-12 by 4-5 mu.— H 68, Vermilion lake. On decaying petioles.

C. Sydowiana Rehn. grows also on petioles, and has much the same microscopical characters except that the sporidia are broader (5-7 mu) and somewhat curved, but the stem is much shorter and thicker, the perithecium subcyathoid, and the whole plant pale. *C. calopus* Fckl. is of a different color, and has the asci and sporidia larger, and so of *C. firma* Pers., to both of which species the Minnesota plant bears some resemblance, though its peculiar color and neat appearance enable one to distinguish it even with the naked eye. The measurements of the stem, etc., and notes of color, are from the dry specimens.

Exoascus alnitorquus (Tul.) Sad.—H. 215, Vermilion lake. On Alnus incana.

Geoglossum luteum Pk.—H 195, St. Louis river. In swamps.

Habrostictis ocellata Fckl. (*Stictis lecanora* Fr.)—H 38, Vermilion lake. On Salix discolor. (Determined by *Ellis.*)

Heliotium citrinum Fr.—H 228, Vermilion lake. More distinctly stipitate than usual. (Determined by *Ellis.*)

Patellaria fenestrata C. & P.—H 118, Vermilion lake. On dead twigs of Populus tremuloides.

Peziza agassizii B. & C.—H 179, St. Louis river. On tamarack.

Peziza (Dasys) **borealis** Ellis & Holway (*n. sp.*). Briefly stipitate, about 1 mm. in diameter, globose when dry and nearly closed, densely shagged and fringed with gray hairs, the marginal ones 80-100 mu long, and 2½ mu thick. Disk pale. Asci cylindrical, sessile, 75-80 by 7-8 mu. Paraphyses stout (2½ mu thick), pointed above and slightly exceeding the asci. Sporidia clavate-fusoid, nucleolate, hyaline, straight or a little curved, 2-seriate, 20-22 by 3-4 mu.—H 264, Vermilion lake. On rotten wood, which is overspread with a brown Zygodesmus. We can not say whether the Zygodesmus is accidental or of the nature of a subiculum. When dry it much resembles *Cyphella ravenelii* B.

Peziza carbonaria A. & G.—H 191, St. Louis river. On the ground. (Determined by *Ellis.*)

Peziza cupressi Batsch.—H 225, Vermilion lake. On fallen leaves of Thuya.

Peziza dehnii Rabh.—H 176, Vermilion lake. On living Potentilla.

Peziza fusco-carpa Ellis & Hol.—H 189, St. Louis river. On logs.

Peziza hemispherica Wigg.— H 159, Vermilion lake. On rotten wood.

Peziza macropus Pers. (*P. subclavipes* Phil. & Ellis.)— H 227, Vermilion lake. (Determined by *Ellis.*)

Peziza (Humaria) **olivatra** Ellis & Holway (*n. sp.*). Carnose, about 2 mm. across, attached by a central point, smooth and blackish outside, with the thin margin lighter. Disk concave, dark olive when dry. Asci clavate-cylindrical, 70-75 by 6-7 mu, subsessile. Paraphyses, yellowish-brown, about as long as the asci, scarcely thickened above. Sporidia biseriate, oblong, yellowish-hyaline, rounded at the ends, 6-7 by 1½-2 mu. The margin, when dry, is more or less undulate, but not strongly incurved.— H 269, Vermilion lake. On old stumps.

Peziza repanda Wahl.— H 258, Vermilion lake. On rotten wood.

Peziza scutellata L.— H 149, Vermilion lake. On old logs.

Rhytisma andromeda Fr.— H 186, Vermilion lake. On Andromeda polifolia.

Spathularia flavida Pers.— H 194, St. Louis river. In swamps.

PERISPORIACEÆ.

Erysiphe aggregata (Pk.)— H 51, Vermilion lake. On Alnus incana.

Erysiphe cichoraceorum DC.— H 78, Vermilion lake. On Echinospermum virginicum.

Microsphæra dubi Lev.— H 150, H 242, Vermilion lake. The latter on an undetermined species of Lonicera; the first on L. hirsuta.

Sphærotheca castagnei Lev.— H 46, Vermilion lake. On Rubus hispidus.

Sphærotheca pannosa Lev.— H. 84, Vermilion lake. On Ribes floridum.

OOPHYTA.

PERONOSPOREÆ.

Cystopus bliti (Bivon) Lev.— H 134, Vermilion lake. On Amarantus retroflexus.

Cystopus candidus (P.) Lev.— H 244, Vermilion lake. On Capsella bursa-pastoris.

Cystopus cubicus (Strauss) Lev.— H 241, Vermilion lake. On Cnicus.

Peronospora arthuri Farl.— H 271, Agate bay. On Œnothera biennis.

Peronospora effusa (Grev.) Rabh., var. **minor** Farl.— H 135, Vermilion lake. On Chenopodium album.

Peronospora gangliformis (Bk.) DeB.— H 81, Vermilion lake. On Mulgedium leucophæum.

Peronospora potentillæ De B.— H 86, Vermilion lake. On Geum macrophyllum.

VOLVOCINEÆ.

Volvox globator L.— A 52, Vermilion lake. In water among moss in low grassy spot. (Determined by *Wolle.*)

CONFERVACEÆ.

Chætophora endiviæfolia Ag., var. **ramosissima** Rab.—A 78, Vermilion lake. (Determined by *Wolle.*)

Chætophora pisiformis Ag.—A 191 in part, St. Louis river. In running water. (Determined by *Wolle.*)

Conferva tenerrima Kg.—A 57, Vermilion lake. (Determined by *Wolle.*)

ZYGOPHYTA.

MESOCARPEÆ.

Mesocarpus scalaris Has. (?)—A 173 in part, St. Louis river. Clear running water; sterile. (Determined by *Wolle.*)

DIATOMACEÆ.

Determined by Mr. B. W. Thomas, from a single gathering taken from the running water of a ditch in a sphagnous swamp.

Eunotia lunaris Grun.—A 172 in part, Vermilion lake.

Eunotia prærupta, var. **bidens** Grun.—A 172 in part, Vermilion lake.

Melosira varians Ag.—A 172 in part, Vermilion lake.

Navicula limosa K.—A 172 in part, Vermilion lake.

Navicula limosa K., var. **subinflata** Grun.—A 172 in part, Vermilion lake.

Navicula major K.—A 172 in part, Vermilion lake.

Navicula parva Ralfs.—A 172 in part, Vermilion lake.

Navicula viridis K.—A 172 in part, Vermilion lake.

Stauroneis anceps E.—A 172 in part, Vermilion lake.

Stauroneis phœnicenteron E.—A 172 in part, Vermilion lake.

Tabellaria fenestrata K.—A 172 in part, Vermilion lake.

Tabellaria flocculosa K.—A 172 in part, Vermilion lake.

DESMIDIEÆ.

Determined by Rev. Francis Wolle.

Closterium dianæ Ehrb.—A 190 in part, Vermilion lake. Ditch in sphagnous swamp.

Closterium parvulum Nag.—A 184 in part, A 190 in part, Vermilion lake. In sphagnous swamp.

Closterium striolatum Ehrb.—A 149 in part, St. Louis river. A 190 in part, Vermilion lake.

Closterium venus Kg.—A 184 in part, Vermilion lake. In cold sphagnous swamp.

Cosmarium botrytis Menegh.—A 184 in part, Vermilion lake.

Cosmarium cucumis Cda.—A 184 in part, Vermilion lake.

Cosmarium nasutum Nord.—A 189 in part, St. Louis river. In open sphagnous swamp.

Cosmarium nitidulum De Not.—A 187 in part, St. Louis river. In sphagnous swamp.

Cosmarium ornatum Ralfs.—A 173 in part, St. Louis river.

Cosmarium speciosum Lund., var. **abbreviatum** Wolle (*n. var.*). Differs from the type-form in being only about one-tenth longer than broad; not one-half longer, as described by Lundell, and as hitherto found.—A 149 in part, A 173 in part, St. Louis river. In clear water running through a ditch in a sphagnous swamp.

Cosmarium tetraophthalmum (Kg.) Breb.—A 184 in part, Vermilion lake. A 189 in part, St. Louis river.

Docidium trabecula (Ehrb.) Nag.—A 149 in part, St. Louis river. A 190 in part, Vermilion lake.

Euastrum ansatum (Ehrb.) Ralfs.—A 190 in part, Vermilion lake.

Euastrum crassum (Breb.) Kg.—A 196 in part, St. Louis river. In clear water running through sphagnous swamp.

Euastrum elegans Kg.—A 189 in part, St. Louis river.

Euastrum oblongum Ralfs.—A 149 in part, St Louis river. A 190 in part, Vermilion lake.

Euastrum verrucosum (Ehrb.) Ralfs.—A 173 in part, St. Louis river.

Penium closterioides Ralfs.—A 192 in part, St. Louis river. In clear water in a sphagnous swamp.

Penium oblongum De B.—A 187 in part, A 188, St. Louis river.

Staurastrum alternans Breb.—A 149 in part, St. Louis river.

Staurastrum brevispina Breb.—A 192 in part, St. Louis river.

Staurastrum dejectum Breb.—A 190 in part, St. Louis river.

Staurastrum dickiei Ralfs.—A 149 in part, St. Louis river.

Staurastrum furcigerum Breb.—A 190 in part, Vermilion lake.

Staurastrum hirsutum (Ehrb.) Breb.—A 173 in part, St. Louis river.

Staurastrum orbiculare (Ehrb.) Ralfs.—A 190 in part, Vermilion lake.

Staurastrum rugulosum Breb.—A 184 in part, Vermilion lake.

Staurastrum scabrum Breb.—A 191 in part, St. Louis river. Clear water in sphagnous swamp.

Staurastrum spongiosum Breb.—A 190 in part, Vermilion lake.

Staurastrum subarcuatum Wolle.—A 190 in part, Vermilion lake.

Staurastrum teliferum Ralfs.—A 184 in part, Vermilion lake. A 190 in part, St. Louis river.

PANDORINEÆ.

Pandorina morum Bory.—A 54, Vermilion lake. (Determined by *Wolle.*)

PROTOPHYTA.

PALMELLACEÆ.

Tetraspora lubrica Ag., var. **lacunosa,** Chauv.—A 192 in part, St. Louis river. In clear flowing water. (Determined by *Wolle.*)

CHROOCOCCACEÆ.

Merismopedia elegans A. Br. (?)—A 190 in part, Vermilion lake. (Determined by *Wolle.*)

OSCILLARIACEÆ.

Leptothrix ochracea Kg. (*Lyngbya ochracea* Thur.)—A 58, Vermilion lake. (Determined by *Wolle.*)

Oscillaria gracillima Kg.—A 56, Vermilion lake. (Determined by *Wolle.*)

Oscillaria tenerrima Kg.—A 76, A 109, Vermilion lake. (Determined by *Wolle.*)

RIVULARIACEÆ.

Glœotrichia natans Thur.—A 186, Vermilion lake. Floating in the water of the lake; from the size of a pea to two inches in diameter. (Determined by *Wolle.*)

Glœotrichia pisum Thur. (*Rivularia fluitans* Cohn.)—A 77, Vermilion lake. Floating in the lake in small quantity; not found attached. This is the same plant that has attracted so much attention at Waterville, Minn., and vicinity, on account of its supposed poisonous effects upon cattle—a supposition that has not been substantiated.

NOSTOCACEÆ.

Nostoc lichenoides Vauch.—A 148, St. Louis river. On the ground among moss. (Determined by *Wolle.*)

MYXOMYCETES.

Arcyria cinerea (Bull.) Rostf.—H 124, Vermilion lake. (Determined by *Rex.*)

Arcyria nutans Bull.—H 64, Vermilion lake.

Arcyria œrstedii Rostf.—H 92, Vermilion lake. (Determined by *Rex.*)

Arcyria punicea Pers.—H 7, Duluth.

Chondrioderma michelii (Lib.) Rostf., var. **sessilis** Rostf.—H 167, Vermilion lake. (Determined by *Rex.*)

Clathroptychium rugulosum (Wall.) Rostf.—H 261, Vermilion lake.

Comatricha pulchella Bab. (?)—H 126, Vermilion lake. (Determined by *Rex.*)

Cribraria argillacea Pers.—H 170, Vermilion lake. (Determined by *Rex.*

Diachæa leucopoda (Bull.) Rostf.—H 6, Duluth.

Dictydium cernuum (Pers.)—H 129, Vermilion lake.

Hemiarcyria clavata (Pers.) Rostf.—H 174, Vermilion lake.

Hemiarcyria rubiformis (Pers.) Rostf.—H 199, Vermilion lake.

Lamproderma arcyrioides (Somf.) Rostf.(?)—H 123, Vermilion lake. (Determined by *Rex.*)

Lycogala epidendrum Brex.—H 56, Vermilion lake. On decayed wood.

Stemonites dictyospora Rostf.—H 33, Vermilion lake.

Stemonites ferruginea Ehr.—H 168, H. 169, Vermilion lake. The latter has spores unusually small. (Determined by *Rex.*)

Tilmadoche nutans Pers.(?)—H 127, Vermilion lake. (Determined by *Rex.*)

Trichia chrysosperma Bull.—H 121, H 202, Vermilion lake. The l
ter varies considerably from the typical form.

Tubulina cylindrica Bull.—H 171, St. Louis river.

CHYTRIDINEÆ.

Synchytrium asari Arthur & Holway (*n. sp.*). Spots indistinct; ga
flattened hemispherical, scattered; resting spores solitary, spherical, .10-.12 m
in diameter; epispore dark brown, smooth.—A 86, Vermilon lake. On lea
and petioles of Asarum canadense.

The galls are formed by the swollen epidermal cells surrounding the ho
cell, and are depressed in the centre, apparently forming a pore. They
thickly scattered over the petiole and both surfaces of the leaf, either over t
whole leaf, which is the usual way; or over definite portions of it. The color
the leaf is scarcely altered, but the affected leaves are made conspicuous by t
minutely blistered and somewhat distorted appearance given by the parasi
The spores are very uniform in size and shape.

INDEX TO GENERA.

INDEX TO GENERA.—*Continued.*

INDEX TO GENERA.—*Continued.*

PLANTS COLLECTED OR OBSERVED ON THE BLUFF AT DULUTH, JULY 17, 1886.

BY L. H. BAILEY, JR.

The following plants were observed upon the high receding bluff just back of Duluth. The original timber has long been removed, the present ligneous plants consisting of scattered clumps of bushes.

Juncus bufonius *L.*
Juncus tenuis *Willd.*
Anaphalis margaritacea *Benth. & Hook.*
Cerastium viscosum *L.*
Taraxacum officinale *W.*
Cornus canadensis *L.*
Quercus rubra *L.*
Thuya occidentalis *L.*
Acer saccharinum *Wang.*
Acer spicatum *Lam.*
Corylus rostrata *Ait.*
Abies, species undeterminable. A few small plants.
Fragaria vesca *L.* Common.
Fragaria virginiana *Ehrh.* Not common.
Potentilla norvegica *L.*
Achillea millefolium *L.*
Trifolium repens *L.*
Trifolium pratense *L.*
Polygonum aviculare *L.*
Plantago major *L.*
Pteris aquilina *L.*
Rumex acetosella *L.*
Aquilegia canadensis *L.*
Rubus strigosus *Michx.*
Rubus nutkanus *Moc.* Common.
Salix discolor *Muhl.*
Epilobium coloratum *Muhl.*
Epilobium spicatum *Lam.*
Capsella bursa-pastoris *Mœnch.*
Verbascum thapsus *L.*
Chenopodium album *L.*
Prunus pennsylvanica *L.* Much attacked by the fungus *Plowrightii morbosa* Sacc.
Diervilla trifida *Mœnch.*

Ranunculus abortivus *L.*
Geranium robertianum *L.*
Cnicus lanceolatus *Hoffm.*
Amarantus albus *L.*
Galium aparine *L.*
Cornus alternifolia *L.*
Heracleum lanatum *Michx.*
Sambucus canadensis *L.*
Betula papyrifera *Marshall.*
Tilia americana *L.*
Carex deweyana *Schw.*
Carex arctata *Boott.*
Carex pennsylvanica *Lam.*
Carex tenella *Schk.* In sunny, dry places.
Agrostis scabra *Willd.*
Phleum pratense *L.*
Polygonum cilinode *Michx.*
Juncus bufonius *L.*
Galeopsis tetrahit *L.*
Lathyrus paluster *L.*
Poa compressa *L.*
Stellaria borealis *Bigelow.*
Polygonum aviculare *L.* A singular, erect, short-jointed form.

SUPPLEMENT TO THE FLORA OF MINNESOT

BY WARREN UPHAM.

The following notes, chiefly received from the botanists nan on pages 10 and 181 of my *Flora of Minnesota*, show the accessi to the known flora of this state, and to knowledge of the g graphic range of species, since the publication of that rep two years ago, without, however, including the plants collec at Vermilion lake and vicinity by the botanical party of State Survey, during the season of 1886. Twenty-two localit are added on the authority of Mr. L. R. Moyer and sister, Montevideo, who have furnished a catalogue of species grow in Chippewa county.

Descriptions of the plants added are found either in Gra *Manual* or in Coulter's *Manual of Rocky Mountain Botany*, exce ing three, of which descriptions are here given.

ACCESSIONS.

Anemone nudicaulis, Gray. "I wish to direct the attention of any o own botanists, who may next summer be visiting lake Superior, to a sing Anemone which grows in bogs and on banks near the water at Sand Minnesota, very near lat. 48°, and in or near the Canadian boundary. know of it is from a specimen sent to me in a letter, dated August 8, 1 from Mr. Joseph C. Jones, then of the U. S. Steamer *Search*. He w that the plant was found growing in mossy ground, close to the wat edge, and also in bogs, and that it grows in the manner of Coptis trif I believe it has filiform rootstocks, like those of Anemone Richardsoni, the radical leaves are so like those of that species that I inadvertently took the plant for that species. But the involucre consists of a single olate leaf, very like the radical, or else is wholly wanting. And the ak are tipped with rather short and hooked styles, very unlike the long of the aforesaid Arctic species. A flowering specimen is a desideratum. *Asa Gray* in *Botanical Gazette*, xi, 17, Jan., 1886.

Arabis patens, Sullivant. Rock Cress.

Nicollet county, in a deep ravine beside a water-fall near the Minne river, five miles above Mankato, *Leiberg*.

Crotalaria sagittalis, L. Rattle-box.

Shore of a little pond close to Mahtomedi station, *Miss Butler*.

Trifolium agrarium, L. *Yellow Clover. Hop Clover.*

Ramsey county, *Oestlund*.

Trifolium procumbens, L., var. *minus*, Koch. *Smaller Yellow* or *Hop Clover*.

Stearns county, *Campbell;* becoming abundant in some parts of south Minnesota, specially observed near Winnebago City (displacing Mayw and other weeds, "even more rapidly than white clover"), *Gedge;* Pi stone City, *Mrs. Bennett*.

Rosa blanda, Ait. (Including var. pubescens, Crepin.) Wild Rose.

Duluth, *Engelmann*. Probably frequent in eastern and northern Minnesota, "on rocks and rocky shores of rivers and lakes." It ranges from Newfoundland, Hudson bay and lake Winnipeg, south to Vermont, northern New York, Illinois and Wisconsin. *Watson* in *Proc. Am. Acad. of Arts and Sciences*, xx, 339, Jan., 1885. Winona county, *Holzinger*.

Rosa Sayi, Schweinitz. Wild Rose.

Surely in northern Minnesota. Frequent in the Rocky mountains from Colorado to British America, and on the south and north shores of lake Superior and northward. *Watson*, l. c., 340.

Rosa Arkansana, Porter. (R. blanda, Ait., var. setigera, Crepin.) Wild Rose.

Very frequent in the mountains from western Texas and New Mexico to British America, and eastward to the upper Mississippi and Saskatchewan. . . . The most pubescent form of this species is common upon dry prairies from the upper Mississippi westward and to the Saskatchewan. The flowers are here sometimes white. In eastern Minnesota and Iowa it occurs with the receptacle more or less hispid. *Watson*, l. c., 341. Winona county, *Holzinger*.

Rosa Woodsii, Lindl. Wild Rose.

Missouri to Colorado and northward to western Montana, the Saskatchewan and Slave lake, chiefly on the plains and in the valleys.—Minnesota, *Sykes*, near Minneapolis, *Miss Butler;* Dakota, *Nicollet*, at Mandan, *Meehan;* Montana, on Tongue river, *Roberts*, etc. *Watson*, l. c., 345.

[The four preceding species take the place of the two varieties of R. blanda.]

Œnothera biennis, L., var. **cruciata,** Torr. & Gray. Evening Primrose.

Willow brook, between Glyndon and Muskoda, Clay county, *Gedge*.

Erigenia bulbosa, Nutt. Harbinger-of-Spring. Pepper-and-salt.

Lake City, *Miss Manning*. Southeast.

Petasites palmata, Gray. (Nardosmia palmata, Hook.) Sweet Coltsfoot.

Tower, Vermilion lake, and Agate bay on lake Superior, *Sandberg;* near Duluth (abundant), *W. H. Stultz;* Leech lake and White Earth, *Dr. C. P. Allen;* Detroit, *W. W. Cooke*. North.

Aster acuminatus, Michx. Aster.

White Earth, *Dr. C. P. Allen*. North.

[Cacalia suaveolens, L., is found at Hesper, Iowa, close to the south line of Fillmore county, Minnesota, by *Mrs. Carter*.]

Senecio aureus, L., var. **borealis,** Torr. & Gray. Golden Ragwort.

Northwest angle of the Lake of the Woods, at the extreme northern point of Minnesota, *Macoun*. North.

Crepis runcinata, Torr. & Gray. Crepis.

Red river prairie and westward, *Dawson*, *Macoun*. West.

Lactuca Ludoviciana, DC. Wild Lettuce.

Winona county, *Holzinger*.

Campanula rotundifolia, L., var. **arctica,** Lange. (var. linifolia, Gray.) Harebell. Bluebell.

North shore of lake Superior, *Roberts;* Clay county, *Gedge;* "quite common in the whole prairie region extending from Manitoba to the Rocky mountains," *Macoun*.

Plantago major, L., var. **Asiatica,** Decaisne. Plantain.

Plentiful in the Red river valley, *Upham*, *Leiberg*. Northwest. Capsule

usually more broadly ovoid; circumscissile near the base and much within the calyx. A very large indigenous form, perhaps a distinct species.—*Gray's Synoptical Flora of N. A.*

Pentstemon cristatus, Nutt. Beard-tongue.

Rising ground, Red river prairie and westward, *Dawson*. *Macoun's Catalogue of Canadian Plants*. West.

Pentstemon gracilis, Nutt. . Beard-tongue.

On the 49th parallel near Emerson, Manitoba, and westward, *Burgess*, *Richardson*, etc. *Macoun's Catalogue*. West. Winona, *Holzinger*.

Monarda fistulosa, L., var. **mollis,** Benth. Wild Bergamot.

Red river valley, *Macoun*. West.

Gentiana Amarella, L., var. **stricta,** Watson. Gentian.

Frequent, or common, in northeastern Dakota, extending south to the Northern Pacific railroad, *Upham;* surely also extending into Minnesota. Northwest. "Frequent on open, grassy prairies from Winnipeg westward to the Rocky mountains. Easily distinguished by its strict habit and usually copious and light-colored flowers." *Macoun's Catalogue*.

Atriplex patula, L., var. **hastata,** Gray. Atriplex.

Common, or frequent on alkaline land in the Red river valley, *Upham;* determined by *Mr. Watson*.

Atriplex argentea, Nutt. Atriplex.

With the preceding, *Upham;* also determined by *Mr. Watson*. West.

Suæda depressa, Watson, var. **erecta,** Watson. Sea Blite.

Common, or frequent, on alkaline land in the Red river valley, *Upham*. Northwest.

Rumex obtusifolius, L. Bitter Dock.

Winona county, *Holzinger*.

Euphorbia platyphylla, L. *Spurge*.

Lake City (rare.), *Miss Manning*.

Salix cordata, Muhl., var. **vestita,** Anders. Diamond Willow.

Frequent, especially in the Red river valley. *Mr. Bebb* writes: "Prof. L. F. Ward and myself are utterly unable to account for the arrest of wood growth at the base of the atrophied twigs." This is not regarded by Mr. Bebb as worthy of a distinct varietal name. It is, however, very well known in many localities because of its diamond-shaped gnarls, which give its name, and make it a curiosity when used for canes or ornamental work.

Typha angustifolia, L. Narrow-leaved Cat-tail.

Rare on north shore of north half of Red lake (leaves ¼ to ⅓ inch wide; staminate and pistillate parts of spike separated by ¾ inch of naked stem), *Upham*.

Sisyrinchium anceps, Cav. Blue-eyed Grass.

Sisyrinchium mucronatum, Michx. Blue-eyed Grass.

Prof. Coulter writes: "Our Sisyrinchiums are unquestionably two species. Very likely Miller's name should be substituted for one of them, but it is impossible without a half day's work in the library to tell which. They are both undoubtedly distinct from the Jamaica plant."

Carex* gynocrates, Wormskiold. Sedge.

Becker county, *Simmons;* determined by *Prof. Arthur*. North.

* Prof. L. H. Bailey, Jr., authorizes a correction in his *Synopsis of North American Carices*, in which Minnesota is credited with *Carex rariflora*, Smith (p. 94), and *C. pratensis*, Drej. (p. 147). Further examination of the specimens from the Minnesota localities cited shows that an error was made in the original determinations, and the citations should therefore be erased.

Carex pauciflora, Lightfoot. Sedge.

Tower, Vermilion lake, and Agate bay, *Sandberg*. North.

Carex rosea, Schk., var. **radiata,** Dewey. Sedge.

Saint Cloud, *Campbell;* determined by *Mr. William Boott.* "More common than the species," *Bailey.*

Carex stenophylla, Wahl. Sedge.

Red river valley, *Leiberg;* determined by *Mr. Boott.* Emmet county, Iowa (rare), *Cratty;* determined by *Prof. Bailey.* West.

Carex adusta, Boott, var. **glomerata,** Bailey. Sedge.

Northern Minnesota, *Bailey.* Spikes few-flowered, aggregated into a loose, mostly tawny head; perigynium large, almost wingless, nearly filled by the large dark achenium.— *Bailey's Preliminary Synopsis of North American Carices.*

Carex straminea, Schk., var. **mirabilis,** Tuckerman. (C. cristata, Schk., var. mirabilis, Gray's *Manual.*)

Chisago county, *Sandberg.*

Carex flava, L. Sedge.

Saint Cloud, *Campbell;* determined by *Mr. Boott.*

Carex trichocarpa, Muhl. Sedge.

Chisago county, *Sandberg.*

Carex vesicaria, L. Sedge.

Red river valley, *Leiberg;* determined by *Mr. Boott.* Northwest.

Carex Tuckermani, Boott. Tuckerman's sedge.

Chisago county, *Sandberg.*

Carex rupestris, All. Sedge.

Red river valley, *Leiberg;* determined by *Mr. Boott.* North.

Stipa viridula, Trin. Feather-grass.

Frequent on alluvial soil in northeastern Dakota, from Grand Forks county northward, *Upham;* doubtless also reaching into Minnesota. West.

Milium effusum, L. Millet-grass.

Hennepin county, *Oestlund.*

Erasures.

The following should be erased:

Thalictrum Cornuti, L. The range of this species (T. polygamum, Muhl.) is stated by Prof. Trelease (*Botanical Gazette*, xi, 92) as "west to Ohio, but mostly confined to the Atlantic states;" it is probably not found in Minnesota. The specimens heretofore referred here belong to T. purpurascens, L.

Cardamine rotundifolia, Michx., in appendix. The C. rhomboidea, DC., var. purpurea, Torr., placed under this name, belongs with the typical C. rhomboidea.

Fragaria Virginiana, Duchesne. Our form of this is the var. Illinoensis, Gray. "The species seems to be confined to the Atlantic states," Coulter's *Manual.*

Cratægus tomentosa, L., var. pyrifolia, Gray. This variety is included with the typical species by Sargent's *Forest Trees of N. A.*

Gaillardia pinnatifida, Torr. The specimens referred here were undoubtedly G. aristata, Pursh.

Trillium erectum, L., var. album, P. Transfer the locality "Winona, *Holzinger*" from this species to T. grandiflorum, *Salisb.*

Carex straminea, Schk., var. Crawei, Boott. This variety is included with the typical species by Bailey's *Synopsis of N. A. Carices.*

ADDITIONAL LOCALITIES.

Ranunculus affinis, R. Br., Two Harbors, lake Superior, *A. W. Jones.*

Ranunculus repens, L., var. hispidus, Torr. & Gray. Frequent in Blue Earth county, *Leiberg.*

Corydalis glauca, Pursh. Brown county, *Juni.*

Arabis lævigata, Poir. White Earth, *Dr. C. P. Allen.*

Sisymbrium Thaliana, Gay. Brown county, *Juni.*

Draba Caroliniana, Walt., var. micrantha, Gray. Common in Blue Earth county, *Leiberg.*

Vesicaria Ludoviciana, DC. Montevideo, Chippewa county, *Moyer.*

Viola lanceolata, L. Near the international boundary northeast of Vermilion lake, *A. W. Jones.* The northern limit of this species, as stated by *Dr. Gray*, is "from Nova Scotia to lake Superior," *Bot. Gaz.*, xi, 255.

Viola palmata, L.

Gray's revision of the violets (*Botanical Gazette*, xi, p. 254) makes it necessary to transfer the localities under V. cucullata, var. palmata of the catalogue to this species, to which should be added Winona county, *Holzinger.*

Viola palmata, L., var. cucullata, Gray. This name should be used instead of V. cucullata, *Gray, l. c.*

Viola sagittata, Ait. Leech lake, *Allen.*

Viola Canadensis, L. Abundant near Cannon lake, Rice county, *Miss Beane.* Quite plentiful in timbered bottoms, some varieties nearly white, Chippewa county, *Moyer.*

Viola pubescens, Ait., var. eriocarpa, Nutt. The prevailing form of this species in copses throughout the prairie part of the state, *Leiberg.*

Hudsonia tomentosa, Nutt. Sandy lake, close northeast of Minneapolis, *Simmons.*

Lechea minor, Walt. Common at Red lake, *Upham.*

Hypericum ellipticum, Hook. Dellwood, Ramsey county, *Kelley.*

Hypericum corymbosum, Muhl. Red Wing, *Sandberg.*

Arenaria Michauxii, Hook. White Earth, *Allen.*

Stellaria crassifolia, Ehrh. Lake City, *Miss Manning.*

Cerastium oblongifolium, Torr. Montevideo, Chippewa county, *Moyer.*

Malva sylvestris, L. Montevideo, Chippewa county, *Moyer.*

Linum perenne, L. Mahtomedi, Ramsey county, *Miss Butler.*

Ptelea trifoliata, L. Faribault, *Miss Beane.*

Rhus typhina, L. Red lake, near the Agency, *Upham.*

Rhus glabra, L. Plentiful near Tower, Vermilion lake, *A. W. Jones.*

Acer rubrum, L. Montevideo, Chippewa county, *Moyer.*

Trifolium arvense, L. Minneapolis, *Simmons.*

Trifolium hybridum, L. Near Duluth, *David F. Day.*

Melilotus alba, Lam. "Spreading along the roadsides in some parts of Cottonwood county to the exclusion of every other plant," *Juni.*

Dalea alopecuroides, Willd. Worthington, becoming plentiful as a weed beside roads in 1885, but rare in 1886, *Foote.*

Petalostemon villosus, Nutt. Winona county, *Mrs. Dice.*

Astragalus flexuosus, Doug. Montevideo, Chippewa county, *Moyer.*

Hedysarum boreale, Nutt. White Earth, *Allen.*

Lathyrus maritimus, Bigelow. North half of Red Lake, *Upham.*

Lathyrus paluster, L., var. myrtifolius, Gray. Chippewa county, *Moyer.*

Phaseolus perennis, Walt. Lake City, *Miss Manning.*

Cratægus Crus-galli, L. Montevideo, Chippewa county, *Moyer.*

Ribes gracile, Mx. Chippewa county, *Moyer.*

Gaura coccinea, Nutt. Brown county, *Juni.* Chippewa county, *Moyer.*

Œnothera fruticosa, L. Lake City, *Miss Manning.*

Œnothera albicaulis, Nutt. Quite abundant, probably introduced, between ilyndon and Muskoda, *Gedge;* a frequent weed along railroads and in wheat-elds in northeastern Dakota, *Upham.*

Ludwigia palustris, Ell. Lake City, *Miss Manning.*

Opuntia fragilis, Haw. Lake of the Woods, in numerous localities, as re-orted by *Prof. Macoun* in letter, Dec. 2, 1884. (See note under O. Rafinesquii.)

Sicyos angulatus, L. Red lake, *Upham.*

Polytænia Nuttallii, DC. Dellwood, Ramsey county, *Kelley.*

Archemora rigida, DC. Winona county, *Holzinger.*

Pimpinella integerrima, Benth. & Hook. Leech lake, *Allen.*

Cryptotænia Canadensis, DC. White Earth, *Allen;* frequent in northeast-rn Dakota, *Upham.*

Aralia racemosa, L. Abundant at Leech lake and White Earth, *Allen.*

Cornus florida, L., in appendix. *Mr. J. S. Harris* reports that at least one ree of this species formerly grew in Houston county.

Lonicera Sullivantii, Gray. Leech lake and White Earth, *Allen;* Manitoba, *facoun.*

Adoxa Moschatellina, L. Duluth, *W. H. Stultz;* determined by *Prof. T. C. 'orter.*

Galium Aparine, L. White Earth, *Allen.*

Galium trifidum, L., var. pusillum, Gray. Vermilion lake, *A. W. Jones.*

Houstonia purpurea, L., var. longifolia, Gray. Chippewa county, *Moyer.*

Houstonia purpurea, L., var. ciliolata, Gray. Moose lake, Northern Pacific unction, and Agate bay, *Sandberg.*

Liatris spicata, Willd. Chippewa county, *Moyer.*

Liatris punctata, Hook. Lake Calhoun, Minneapolis, *Miss Butler;* Lake City rare), *Miss Manning.* Chippewa county, *Moyer.*

Kuhnia eupatorioides, L. Leech lake, *Allen.* Chippewa county, *Moyer.*

Kuhnia eupatorioides, L., var. corymbulosa, Torr. & Gray. Common in the rairie region of the state, *Leiberg.*

Eupatorium perfoliatum, L. Common at Red lake, *Upham.*

Petasites sagittata, Gray. White Earth, *Allen;* abundant near Hollson, Pem-ina county, Dakota, *Upham.*

Aster patens, Ait. Lake City (rare), *Miss Manning.*

Aster cordifolius, L. Rare or absent in the north part of the Red river val-y, but frequent at Red lake, *Upham,* that being near its northwestern limit; eech lake and White Earth, *Allen.*

Aster puniceus, L. White Earth, *Allen;* common at Saint Hilaire and fre-uent at Red lake and in northeastern Dakota, *Upham;* doubtless also frequent

in the Red river valley. Its range extends west to the Rocky mountains in British America, *Macoun.*

Aster oblongifolius, Nutt. White Earth, *Allen;* Northeastern Dakota, *Upham.* Infrequent. South and west. Chippewa county, *Moyer.*

Aster linariifolius, L. Lake City, *Miss Manning.*

Solidago Missouriensis, Nutt. Montevideo, Chippewa county. *Moyer.*

Aplopappus spinulosus, DC. Abundant on dry, gravelly soil, as the beaches of lake Agassiz, in northeastern Dakota, *Upham.* West.

Polymnia Canadensis, L. Winona county, *Holzinger.*

Lepachys columnaris, Torr & Gray. Chippewa county, *Moyer.*

Coreopsis tinctoria, Nutt. Dellwood; Ramsey county, *Kelley.*

Coreopsis trichosperna, Michx. Lake City, *Miss Manning.*

Bidens Beckii, Torr. Vermilion lake, *A. W. Jones;* Lake City (rare), *Miss Manning.*

Artemisia frigida, Willd. Winona county, *Holzinger.*

Cacalia atriplicifolia, L. Lake City, *Miss Manning.*

Senecio aureus, L., var. obovatus, Torr & Gray. Vermilion lake, *A. W. Jones.*

Senecio canus, Hook. "Very abundant on many parts of the prairie region from the eastern part of Manitoba to the Rocky mountains," *Macoun.*

Cnicus undulatus, Gray. Chippewa county, *Moyer.*

Prenanthes crepidinea, Michx. Lake City, *Miss Manning.*

Lobelia Dortmanna, L. Burntside lake, Saint Louis county, *A. W. Jones.*

Campanula aparinoides, Pursh. The large-flowered form occurs at Vermilion lake, *A. W. Jones.*

Gaylussacia resinosa, T. & G. Winona county, *Holzinger.*

Epigæa repens, L. Near Red lake (rare), *Upham;* also, at an isolated locality in Plainview, Wabasha county, *Miss Manning.*

Kalmia glauca, Ait. Agate bay, lake Superior, and Vermilion lake, *Sandberg.*

Pyrola rotundifolia, L., var. incarnata, DC. Leech lake, *Allen;* common in swamps, Vermilion lake, *A. W. Jones.*

Pyrola rotundifolia, L., var. uliginosa, Gray. Common at Vermilion lake, *A. W. Jones.*

Monotropa uniflora, L. Rare northwestward; only one specimen found at White Earth, none about Red and Leech lakes, *Allen.*

Anagallis arvensis, L. Lake City (rare), *Miss Manning.*

Pentstemon grandiflorus, Nutt. Goodhue county, *Mrs. Richardson.*

Pentstemon acuminatus, Dougl. Chippewa county, *Moyer.*

Gerardia Skinneriana, Wood. Dellwood, Ramsey county, *Kelley.*

Phryma Leptostachya, L. White Earth, *Allen.*

Monarda punctata, L. Winona county, *W. C. Scott.*

Scutellaria versicolor, Nutt. Minnesota side of lake Pepin, 1885, *Miss Manning.*

Leonurus cardiaca, L. Leech lake, *Allen.*

Onosmodium Carolinianum, DC., var. molle, Gray. Frequent in northeastern Dakota, *Upham,* and in Manitoba, *Macoun.*

Mertensia paniculata, Don. Vermilion lake, *A. W. Jones.*

Myosotis verna, Nutt. Redstone, near New Ulm, *Juni.*

Gilia linearis, Gray. (Collomia linearis, Nutt.) Fort Francis on rainy river, and westward, *Macoun;* Red river prairie, *Dawson;* also, much east from its principal range, at Cannon Falls and Red Wing, *Sandberg.*

Calystegia sepium, L., var. repens, Gray. Lake of the Woods and westward, *Dawson.*

Physalis Virginiana, Mill., var ambigua, Gray. Plentiful on sandy land between Mankato and Minneopa falls, *Leiberg.*

Nicandra physaloides, Gærtn. Red Wing, *A. W. Jones;* Chippewa county. *Moyer.*

Asclepias speciosa, Torr. East side of Loon lake, Blue Earth county, *Gedge;* Chippewa county, *Moyer.*

Chenopodium rubrum, L. Frequent on alkaline land in the Red river valley, *Upham;* determined by *Mr. Watson.* Our plant is the typical species, not the var. humile.

Salicornia herbacea, L. Infrequent, but in some places plentiful, on salty and alkaline moist land in the northern part of the Red river valley, *Upham.*

Amarantus blitoides, Watson. Lake City, *Miss Manning.*

Rumex salicifolius, Weinman. Vermilion lake, *A. W. Jones;* Chippewa county, *Moyer.*

Rumex verticillatus, L. Lake City, *Miss Manning.*

Ceratophyllum demersum, L. Red river valley, *Leiberg.*

Euphorbia glyptosperma, Engelm. Winona county, *Holzinger.*

Bœhmeria, cylindrica Willd. Dellwood, Ramsey county, *Kelley.*

Betula nigra, L. The first three localities given for this should be transferred to B. lutea.

Pinus Banksiana, Lamb. Rev. F. W. Smith of Red Lake Agency states that "watab" (see under Larix Americana) is mainly roots of this species of pine; but he says that roots of both tamarack and arbor vitæ are also used in the same way, all being alike called "watab." Watab river and township no doubt refer to the "jack pines" there.

Juniperus communis, L. Red lake (rare), *Upham.*

Zannichellia palustris, L. Doubtless common throughout the state, but overlooked, *Leiberg.*

Potamogeton Claytonii, Tuckerman. Vermilion lake, *A. W. Jones.*

Potamogeton lonchites, Tuckerman. Winona county, *Holzinger.*

Triglochin maritimum, L., var. elatum, Gray. Frequent at Saint Hilaire and northwestward, *Upham.*

Habenaria tridentata, Hook. White Bear lake, *Bailey.*

Spiranthes Romanzoffiana, Chamisso. Lake City, *Miss Manning.*

Arethusa bulbosa, L. Aitkin, *Miss Beane;* Lake City, *Miss Manning.*

Cypripedium arietinum, R. Br. Lake City, *Miss Manning.*

Uvularia grandiflora, Smith. Common at mouth of Pike river, Vermilion lake, *A. W. Jones.*

Uvularia perfoliata, L. White Earth, *Allen.*

Juncus bufonius, L. Sandy lake, close northeast of Minneapolis, *Simmons.*

Eriocaulon septangulare, With. White Bear lake, Ramsey county, *Kelley;* in a little pond close to Mahtomedi station (plentiful), *Miss Butler.*

Eleocharis pauciflora, Watson. Red river valley, *Leiberg;* determined by *Mr. Boott.*

Scirpus Torreyi, Olney. White Bear lake, *Bailey.*

Scirpus debilis, Pursh. Saint Cloud, *Campbell;* determined by *Mr. Boott.*

Carex crus-corvi, Shuttleworth. Chisago county, also Red Wing, *Sandberg.*

Carex oligosperma, Michx. Chisago county, *Sandberg*; White Bear lake, *Bailey*.

Cinna pendula, Trin. Swamps in wet woods along the Minnesota river, in Blue Earth county, *Leiberg*.

Brachyelytrum aristatum, Beauv. Minneapolis, *Simmons*.

Oryzopsis melanocarpa, Muhl. Saint Cloud, *Campbell*.

Phalaris Canariensis, L. Winona county, *Holzinger*.

Azolla Caroliniana, Willd. Winona county *Holzinger*.

PLANTS COLLECTED OR OBSERVED ON HUNTERS' ISLAND, BRITISH AMERICA, JULY 26 AND 27, 1886.

BY L. H. BAILEY, JR.

Galeopsis tetrahit *L.* About the ruins of the block house.
Cornus stolonifera *Michx.* Singular forms.
Scirpus eriophorum *Michx.*
Carex lenticularis *Michx.* Along the shore, in clumps.
Carex tribuloides *Wahl.*, var. reducta *Bailey.* Very small form.
Nasturtium palustre *DC.*
Fragaria virginiana *Ehrh.*, var. illinoensis *Gray.*
Melampyrum americanum *Michx.*
Ranunculus aquatilis *L.* In clear lake water, from a hard bottom.
Solidago canadensis *L.*, var. procera *T. & G.*
Agrimonia eupatoria *L.*
Aster macrophyllus *L.*
Spiranthes gracilis *Bigelow.*
Alnus viridis *DC.*
Scutellaria lateriflora *L.*
Elymus canadensis *L.*
Geum nivale *L.*
Fraxinus americana *L.*
Fraxinus pubescens *Lam.*
Acer dasycarpum *Ehrh.*
Amelanchier ——?
Habenaria orbiculata *Torr.*
Lycopus virginiana *L.*
Œnothera biennis *L.*
Vaccinium pennsylvanicum *Lam.* Berries abundant and delicious.
Oryzopsis melanocarpa *Muhl.*
Oryzopsis canadensis *Torr.*
Poa serotina *Ehrh.*
Poa compressa *L.*
Agropyrum violaceum *Vasey.*
Muhlenbergia mexicana *Trin.*
Danthonia spicata *Beauv.*
Glyceria nervata *Trin.*
Glyceria fluitans *R. Br.*
Deyeuxia ——?
Agrostis scabra *Willd.*
Lysimachia stricta *Ait.*

Alnus incana *Willd.*
Gaultheria procumbens *L.*
Solidago lanceolata *L.*
Myrica gale *L.*
Carex retrorsa *Schw.*
Populus tremuloides *Michx.*
Populus grandidentata *Michx.*
Populus balsamifera *L.*
Betula papyrifera *Marshall.*
Hordeum jubatum *L.*
Phleum pratense *L.*
Epilobium coloratum *Muhl.*
Epilobium spicatum *Lam.*
Agrostis vulgaris *With.*
Rubus strigosus *Michx.* Common and productive.
Chenopodium album *L.*
Chenopodium hybridum *L.*
Erigeron canadense *L.*
Pteris aquilina *L.*
Apocynum androsæmifolium *L.*
Diervilla trifida *Mœnch.*
Prunus pennsylvanica *L.* Very common.
Prunus virginiana *L.* Not common.
Corylus rostrata *Ait.*
Bromus ciliatus *L.*
Rhus glabra *L.*
Arctostaphylos uva-ursi *Spreng.*
Antennaria plantaginifolia *Hook.*
Anaphalis margaritacea *B. & H.*
Pinus resinosa *Ait.* Evidently the original timber.
Pinus strobus *L.* Not so common as the last.
Thuya occidentalis *L.* Mostly destroyed.
Linnæa borealis *Gronov.*
Eupatorium purpureum *L.*
Cicuta maculata *L.*
Pyrola chlorantha *Swartz.*
Polygonum cilinode *Michx.*
Salix rostrata *Rich.*
Salix humilis *Marshall.*
Salix petiolaris *Smith.*
Hypericum canadense *L.* Very small form.
Rosa sayi *Schw.*
Rosa blanda *Ait.*

Fm

GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.
N. H. WINCHELL, STATE GEOLOGIST.

BULLETIN No. 4.

SYNOPSIS

OF THE

APHIDIDÆ OF MINNESOTA.

BY O. W. OESTLUND.

ST. PAUL:
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TABLE OF CONTENTS.

ADDRESS.

PROF. N. H. WINCHELL,

DEAR SIR: I have the honor herewith to make another contribution to the entomology of Minnesota.

As neither time nor means are yet at hand to undertake a systematic work of the whole field of entomology, as contemplated by the law creating the survey, I have, as heretofore, given special attention only to some group or family, as circumstances and literature at hand make it possible to do anything like presentable work. The following paper is a second contribution on the family of plant-lice, or Aphididæ, a preliminary list of which was given in the last annual report. The two past seasons have enabled me not only to make some corrections to this list, but also several additions, which I have now put in the form of a synopsis of the family as far as known to occur in Minnesota. I am aware of the fact that shortcomings will be found, and that probably a too hasty conclusion has been drawn in many cases, but, as this is a first attempt of a systematic treatment of our American forms, I have some hopes that it will still be received with favor by all who will have occasion to use it, and that it will prove a valuable contribution to the entomology of Minnesota.

In the introduction I have given some general remarks together with explanations of the terms more commonly used in describing species, that may be of value to the student not already familiar with the terms of entomology. Here I have also added a bibliography of our American authors treating of the family, as far as known to me, which is also, I believe, a first attempt.

The species here treated of were mostly collected along the Mississippi river, but the report can now be considered to apply to the whole state, with the exception of the northern part, or pine district, which has not yet been examined. Two months of the present season spent in the western part of the state, mostly along the lakes Big Stone and Traverse, have enabled me to add many valuable notes from that part of the state.

The gorge of the Mississippi between St. Paul and Minneapolis, formed by the recession of the St. Anthony falls, affords probably as favorable a locality for plant-lice as any that can be found. The steep bluffs on either side give the necessary protection and moisture for a varied and luxuriant growth of vegetation, making a paradise for the aphides as well as the student of these forms. But as the two cities are rapidly extending over this territory and changing the condition of things, I have deemed it fortunate to have had the opportunity to make a thorough collection before a complete change has taken place.

In treating of the family in an ascending order, I have departed from what is customary; but as it is more natural and has advantages there is no need of further apology.

I am under obligations to Mr. Monell, formerly of St. Louis, but now of Mine la Motte, Mo., for many suggestions as well as favors of specimens for comparison. In recognition of Mr. Monell as one of our foremost aphidologists I have named a new genus in honor of him, on the re-discovery of one of Dr. Fitch's species that for the past thirty years has remained a puzzle to entomologists.

O. W. OESTLUND.

UNIVERSITY OF MINNESOTA,
Minneapolis, Minn., September 27, 1887.

INTRODUCTION.

The Aphididæ or plant-lice are small soft-bodied insects, commonly found on the foliage of plants, on the sap of which they feed. Their study is of great importance both from an economic as well as scientific standpoint.

The terms used in treating of the species are in main the same as those used in treating of insects in general; but as some have a special application to this family and a few are peculiar to it, I shall give a short exposition of those terms commonly used in describing species.

The body of plant-lice, as of insects in general, is divided into three principal parts, which are more or less distinct from each other. These parts are the head, thorax, and abdomen.

HEAD. The head is the front portion of the body, and in the family is mostly small, never wider than the thorax. As appendages to the head are to be noticed the antennæ, eyes and beak.

ANTENNÆ. The antennæ are fili-form, jointed appendages inserted in front of the eyes. Some of the best characters for the distinction of both genera and species are drawn from them. In length they vary from hardly longer than the head to more than twice the length of the body. In the number of joints they vary from only three in Phylloxera to seven in the greater number of genera. They are inserted directly on the head, or on a prolonged or raised lobe called the *frontal tubercles* as seen especially in the Nectarophorini. The two basal joints are always short; the third is as a rule the longest, and the fourth, fifth and sixth each respectively shorter; the sixth short, and nearly always with a small contraction at the end called the *unguis* or nail, which is shorter than the joint. The seventh joint of the seven-

jointed antennæ is really the same thing as this unguis of the six-jointed antennæ, but here prolonged so as to be as long or longer than the sixth, and in some of the higher genera even longer than the third. When thus, it is convenient to consider it as a separate joint as is commonly done by entomologists. This joint is always much narrower than the other, setaceous and often imbricated. The relative length of the joints is in most cases quite constant and gives good specific characters, but in some of the higher genera they vary so much that it is only by taking the average of a number of specimens that we can get measurements of any value. On the very tip of the antennæ are always found two short hairs that differ from those of the other joints, and which evidently correspond to the more conspicuous bristles of the Psyllidæ. In nearly all cases the antennæ are found with a fine pubescence scattered over the joints, but not so as to be readily noticed; in only a few cases, as in Chaitophorus, does this pubescence become so decided as to be of generic value. The third joint, and often the fourth, fifth and sixth, are supplied with sense pores, or small circular spots covered by a membrane, and look very much like the ocelli of the head. In the following pages I speak of these as *sensoria*. They are considered by entomologists to be organs of smell or hearing, or both. I have always found them present and they often give very good specific characters, though very few writers have yet made use of them in describing species. In living specimens they are often difficult to observe, but in specimens mounted in Canada balsam they are most beautifully brought out. In form they are usually small circular, but often large oval or irregular, giving to the antennæ a rough or tuberculate surface. They are nearly always restricted to the under side of the joint, and often to a definite number in a single row. Near the tip of the fifth, and at the contraction of the sixth joint, one or more of these sensoria are always to be found. The antennæ of the male is often longer and more highly developed than that of the female.

EYES. The sense of sight is strongly developed in the Aphididæ. The compound eyes are large, hemispherical, situated on the side of the head, and always present except in a few root-inhabiting species, where they are either much reduced in size or altogether wanting. On the back part of each eye some of the lenses are slightly raised above the general surface forming the

ocular tubercles. The winged forms are in addition always provided with three simple eyes or *ocelli*: one near each of the compound eyes, and one on the vertex or front of the head. In many of the lower genera they are not very readily seen, but in some of the higher they are very conspicuous. Why the winged form should be provided with these simple eyes in addition to the compound has not yet been answered to satisfaction, but it appears very probable that they correspond to the nocturnal eyes of the Arachnida, and that it is as such that they are made use of.

BEAK. One of the principal characters of the order to which the present family belongs, is the modification of the mouth parts into a beak by means of which they suck the juices on which they live. The beak is situated on the under side of the head, and when not in use is commonly folded close to the body between the legs. The external part of the beak is composed of three joints, which are channelled on the inner surface for the reception of four very fine piercers or *setæ*, by means of which the leaf or bark is punctured and the sap is drawn up into the body. In length it varies from very short to much longer than the body in some of the foreign species. Some good generic and specific characters can often be drawn from it. It is present in all the forms and in both sexes, with few exceptions.

THORAX. The thorax is the second of the three grand divisions of the body, and is itself divided into three parts or segments. The first of these is the *prothorax*, or the segment next to the head, with which it is united by a membrane that is usual of a paler color. The upper surface of the prothorax is smooth and hard, like the rest of the thorax, and is called the *pronotum*. On either side of the prothorax there is often seen a tubercle which is spoken of as the lateral tubercle, but although its presence or absence is constant, not much use has yet been made of it in classification. This segment supports the first pair of legs and is usually small, narrower than the head, but in Chermes it is as large as the mesathorax and in Monellia almost as well developed. The second segment is the *mesathorax* and is always well developed. It supports the wings together with the second pair of legs. The upper surface is smooth and divided into four lobes, of which the two lateral ones are the largest and contain the strong muscles of the wings; the hindmost lobe, which is usually transverse or triangular in form, is

sometimes referred to as the *scutellum.* The third segment or *metathorax* is closely united with the second, but not much of it is apparent externally. It supports the third pair of legs.

The thorax is sometimes low and flat, on the same level with the rest of the body; again it is much raised or arched as is seen especially in the Pemphegina.

WINGS. The wings are four in number, of which the front pair are much larger than the hind pair. They are membranous, often very thin or hyaline so as to be iridescent. Without color, but often the veins are of a deep black, or with a smoky border on each side; more rarely with spots or patches of black or smoky brown across the disk, as is seen in many of the Callipterini. In the lower genera the wings are short and broad, but in the higher genera they become much longer and narrower. The veins are few in number and afford some of the best characters for the separation into sub-families; they are all smooth, with exception of a series of fine hairs on the sub-costal of the fore-wings that I have noticed in some of the Pemphegina. The first vein running along the front margin of the fore wings, is called the *costal vein;* and parallel with this one is a second vein called the *sub-costal.* This second vein near the apex of the wing expands, uniting with the costal, forming a slightly thickened or darker colored surface called the *stigma.* In some of the Chermesinæ the stigma becomes excessively large, allying them with the half coriaceous wings of the Heteropterous Hemiptera. From the sub-costal there runs across the disk of the fore wings two or three oblique veins called the *discoidal veins.* The two nearest to the insertions of the wings are always simple; the third discoidal, or *cubital vein* as it is also called, is altogether wanting in the Chermesinæ, simple in the Pemphegina, with one branch in the Schizoneurinæ, and with two branches in the two highest sub-families. The short vein arising from the stigma is called the *stigmal vein;* it becomes in a few cases very obscure or subobsolete, very rarely altogether wanting. The veins of the hind wings are made to correspond with those of the fore wings, but there are never more than two discoidals, and the stigma and stigmal veins are also wanting. In normal specimens the veins are very constant, but occasionally abnormal specimens will be found with one or more of the usual veins partly or wholly wanting; or again with supernumerous veins or branches. Thus the cubital vein is sometimes seen with three branches instead of

two; the stigmal has also been found with one branch. By comparing a number of specimens in such cases the normal venation will always become apparent.

The cells, or spaces between the veins, are rarely referred to in descriptions.

On the front margin of the hind pair of wings there is a slightly raised and thickened place from which two or more fine hooks arise, which fasten into a corresponding fold on the posterior margin of the fore wings, thus making a continuous surface of the two wings in flight.

When at rest the wings are, in most cases, held in a slanting perpendicular position over the abdomen; in some cases they are folded flat or horizontally upon the abdomen.

LEGS. The legs are six in number and supported by the thorax, as has already been stated. They are rather short in the lower genera, but long and slender in the higher. Sometimes they are quite smooth, but more commonly with numerous fine hairs, or even hirsute. The first small joint by which they are united to the thorax is called the *coxa;* the first long joint is the *femur* and the second the *tibia.* The tibia supports the *tarsus* which is two jointed, but the second joint is often very small and inconspicuous; the tarsus is always furnished with two long and stout claws. In a single genus, Mastopoda, the tarsi are atrophied, the peculiar structure of which will be more fully treated under the genus.

ABDOMEN. The series of segments following the thorax is called the abdomen and formes the third principal division of the body. In shape it is usually oval or ovoid, and capable of much distention by food, eggs or pseudova, so as to be much larger than the rest of the body. On either side there is often a protruding edge or fold, and when thus the abdomen is said to be margined. The upper surface, or *dorsum,* is often furnished with tubercles or patches of a different color that give us good specific characters. The last segment, especially in the oviparous female, is furnished with two smooth horny plates called the anal plates. In some cases, as in Callipterus, the abdomen is much drawn out into a kind of ovipositor enabling the insect to dispose its eggs between the crevices of the bark. The appendages of the abdomen deserving special mention are the honey-tubes and the style.

HONEY-TUBES. The sixth abdominal segment has on the dorsal side two openings, usually raised more or less above the sur-

face as tubes, called the *honey-tubes.** What their use may be to the insect does not yet seem to be clearly made out, though many curious and ingenious hypotheses have been brought forward by different writers, but which I can not here produce nor discuss. Evidently they are some kind of secretory organs, as the sweet liquid they give off is much sought for by ants. In some cases the honey-tubes are altogether wanting, or simply circular openings on a level with the surface of the abdomen, and often obscured by pulverulent or flocculent matter with which the abdomen in such species is commonly covered. When slightly raised above the surface it is said to be tubercle-like; or when longer than broad it varies from moderately long to very long as is seen in most of the Nectarophorini where they are often half the length of the whole body. In form they are usually cylindrical, but in some cases enlarged near the base, in the middle, or near the apex, when they are said to be clavate. The apex is sometimes simply truncate, again expanding into a narrow flat rim, or more broadly expanding and trumpet-like; more rarely it is round or knob-like. Usually the tubes are opaque, more rarely transparent so that the liquid globules can be seen through them. The surface is smooth and shining, more rarely imbricated.

The honey-tubes, which are so characteristic of the family, give us some of the best characters for the separation of the genera.

STYLE. The last segment of the abdomen is furnished with a more or less prominent process known as the *style*. In some cases, like the honey-tubes, it is wanting, or not to be distinguished from the last segment of the abdomen, but in most cases it is distinct and conspicuous. In form it is often cone-like, as in most of the Aphis; again it is enlarged or rounded at apex, as is seen in Callipterus; when it is widest in the middle and more or less curved upwards, as in most of the Nectarophorini, it is said to be *ensiform* or *falchion-shaped*. The surface is usually smooth, but sometimes wrinkled or imbricated, usually with several long hairs or bristles. In color it agrees in most cases with the abdomen, but occasionally distinct.

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*These appendages are known under several different names. Fitch speaks of them as *horns*; by English writers they are usually called *cornicles*, *nectaries* or *siphuncles*, and most of our own writers speak of them as *nectaries* or *honey-tubes*, the last of which I have used in all my writings on this family.

METAMORPHOSIS.

The four characteristic stages of insect-life in general, the egg, larva, pupa and imago, are greatly modified in the present family, and will require some special terms and explanation. Ordinarily these stages are passed through by each individual, but in the present case the same stages comprise a greater or less number of individuals. Moreover the pupa stage is not well marked; but this can also be said of the whole order of Hemiptera, in which the pupa is active and but slightly differing from the larva, on which account the order is said to have incomplete metamorphosis. The three well marked stages in the life of the Aphididæ are the *egg*, *pseudogyna* and *imago*.

EGG. It is now pretty well established that each species is found in the egg at some time or other, though they are known only in a comparatively few cases. As in other insects, therefore, the egg seems to be the condition in which the winter is more commonly passed. In shape they are usually a long oval, about as long again as broad, rounded at both ends. The surface is very smooth and shining; when first laid pale greenish or yellow, but soon becoming shining black. The number deposited by each individual varies from one to many, but more commonly the number is definite.

PSEUDOGYNA. The young hatching from the egg never develops directly into the true male or female. but is always an asexual or *agamous* form that produces living individuals like itself without the intervention of the male, and which in turn are capable of producing their own kind. This mode of reproduction is continued through a number of generations, and have by Lichtenstein, to whom we are much indebted for what we know on this subject, been called *pseudogynæ* (false females). They are considered as only transitory or larval forms, corresponding to the larval stage of other insects.

The different generations of these pseudogynæ differ often much from each other and have received separate terms for their designation. Lichtenstein recognizes four different forms, though the number varies in different cases. These he calls:

Pseudogyna fundatrix.
Pseudogyna migrans.
Pseudogyna gemmans.
Pseudogyna pupifera.

The first of these (*pseudogyna fundatrix*) is the immediate issue of the fecundated egg. Prof. Riley calls it the stem-mother, as it is the foundress of the colony, which the above name also implies. It is always apterous, and produces the gall in species that live thus protected.

The second form (*pseudogyna migrans*) differs from the first in acquiring wings. Apparently it differs in no respect from an imago, as ordinarily understood in entomology by this term, and in description of species it is made use of as such, though theoretically it is still incomplete or a pseudogyna. This form takes readily to the wings and thus spreads the colony over a greater area.

The third form (*pseudogyna gemmans*) following the second, is again without wings or apterous. It continues often to produce through a number of generations that in all respects are similar to each other. It is often but a counterpart of the first form.

The fourth form (*pseudogyna pupifera*) is the last generation of the pseudogynæ in which the viviparous power is retained, but with which it also terminates. The living larvæ produced by this form develop into the true male and female.

As before said, the number and relation of these generations vary for different genera, and we are yet too little acquainted with the extent of this variation to make statements that would apply to the whole family. In some cases we have at least one, if not more generations, between the first (*fundatrix*) and the second (*migrans*), like the first in being apterous but differing in size and in other respects. In other cases each generation of the pseudogyna, as far as is known, acquire wings before reproducing their own kind, as is the case in Callipterus, Drepanosiphum and Monellia.

In descriptive entomology it has been the custom to speak of the wingless forms of the pseudogyna as the *apterous viviparous female*, and of the winged forms as the *winged viviparous female.* Of the true sexes the female is spoken of as the *oviparous female*, in distinction from the wingless pseudogyna form.

IMAGO. The imago comprises the sexual form, male and female. These as soon as full grown pair, and the female deposits the eggs and thus closes the cycle.

The male is either winged or wingless and often both in the same species. The female is as a rule wingless, and would thus appear to be less developed than even some of the pseudogyna,

but cases similar to this we find in every order of insects, even the highest, as in Lepidoptera and Hymenoptera. Wings are not essential organs and can therefore be wanting in the imago stage.

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SYNOPSIS OF THE APHIDIDÆ

FOUND IN MINNESOTA.

FAMILY APHIDIDÆ.

Antennæ variable in length, three to seven-jointed, filiform, provided with sensoria, ending with two short hairs (*pili sensuales*) that correspond to the two bristles of the Psyllidæ. Eyes large, hemispherical, placed in front of the antennæ, provided with an ocular tubercle. Ocelli three and always present in the winged form. Beak present in both sexes with few exceptions, three-jointed. Wings four in number, membranous, charged with few veins; the front pair much larger than the hind pair. Tarsi two-jointed (except in Mastopoda which has the tarsi atrophied), ending with a double claw. Abdomen with two dorsal openings or honey-tubes on the sixth segment, rarely wanting. Last segment with a more or less prominent process or style.

The six subfamilies more commonly recognized may be separated in the following manner:

1	Winged form unknown; subterranean species. -	RHIZOBIINÆ.
	Winged form known; aerial in habit. - - - - -	2.
2	Antennæ 3–5 jointed; fore wings with only two discoidals.	CHERMESINÆ.
	Antennæ 6 or 7-jointed; fore wings with three discoidals. -	3.
3	The third discoidal simple. - - - -	PEMPHEGINÆ,
	The third discoidal branched. - - - - - -	4.
4	The discoidal with only one branch. - -	SCHIZONEURINÆ.
	The discoidal twice-branched. - - - -	5.
5	Antennæ 6-jointed. - - - - - -	LACHNINÆ.
	Antennæ 7-jointed, rarely only 6-jointed. - - -	APHIDINÆ.

Subfamily RHIZOBIINÆ.

Subterranean species, which never acquire wings as far as known, living on roots of plants. Antennæ short, mostly five-jointed, or six-jointed when the unguis or spur of the fifth is counted as one, as is done by some writers. Beak variable in length; eyes very small, inconspicuous, or none; legs short and stout; tarsi with two claws which are sometimes folded so as to appear as single, or with only one claw in Rhizobius. Honey-tubes wanting. Style inconspicuous or none. Body mostly short, convex above, smooth or sometimes hairy or tufted with setæ or flocculent matter.

It has been customary to put all such subterranean species that are known only in the apterous condition and can not with certainty be classified with any of the higher subfamilies into the one under consideration. But several of these underground species are now known to acquire wings, and have accordingly been been classified with the following subfamilies; it is therefore probable that this will be the case with most, if not all, of the remaining species as they become better known, as we have no substantial character on which to rely except on the supposed permanent apterous condition. Of the five or six genera usually excepted by European entomologists, only two have been recognized so far in this country: Rhizobius and Tychea, the last of which has a representative in Minnesota.

Genus TYCHEA Koch, 1857.

Antennæ short, five-jointed, third joint the longest, or but very little difference in any of them. Eyes none or very rudimentary. Beak rather long and stout. Legs short; tarsi with two claws. Honey-tubes wanting. Style small or none. Body usually broadly oval, convex above, often with tufts of setæ or flocculent matter.

Found mostly on roots of grasses or herbaceous plants, and usually in connection with ants.

1. Tychea radicola Oestlund.

Tychea radicola Oest. Geol. Surv. Minn., 14th Report, p. 56, 1886.

Antennæ five-jointed not counting the spur; third joint the longest, but slightly longer than the fourth. Beak long, reach-

ing to middle of abdomen, dusky at tip. Abdomen rounded, convex above, margined with tufts of white flocculent matter. Style very short, globular and slightly hairy. Color very pale or white.

This species, found on the roots of *Ambrosia trifida*, will be easily recognized on account of the tufts of white waxy matter around the margin of the abdomen.

The following species have been described as American, some of which will require further study to establish them as good species:

Tychea panici Thos., on the roots of *Panicum glabrum*.

Tychea erigeronensis Thos., found on the roots of *Erigeron canadense*, which may be but an immature form ot *Aphis middletonii* common on the roots of the same plant.

Rhizobius lactucæ Fitch, on the roots of lettuce.

Rhizobius poæ Thos., found on the roots of *Poa annua* (?).

Rhizobius eleusinis Thos., on the roots of *Eleusine indica*.

Subfamily CHERMESINÆ.

Antennæ short, five-jointed or only three-jointed in Phylloxera. Beak short, never very long, and sometimes wanting in the perfect sexes. Eyes nearly always large and prominent. Prothorax large, often as much developed as thorax proper. Fore wings with three simple oblique veins; hind wings with a single oblique vein, which sometimes becomes very obscure or entirely wanting. Legs short; tarsi with two claws. Honey-tubes wanting.

The subfamily as here defined includes the Phylloxera, though Lichtenstein and others, who have made a special study of this genus, consider it as the type of a distinct family—the Phylloxeridæ—which I think is likely to be generally accepted as soon as the numerous forms belonging here become better known. But as the subfamily has been very little studied in reference to Minnesota, and besides very little is known in regard to any of the species in this country, I treat of it here as customary, and more to call attention to the subject than to present any additional material.

When the genus Phylloxera be excepted the species are not very numerous, but of much interest as found almost exclusively on the coniferous trees, and presenting many peculiarities in habit and development. As soon as the northern parts of Min-

nesota can be examined, which are covered with coniferous trees, we can expect a rich field, and much valuable matter in our knowledge of these insects.

When Phylloxera be included the subfamily will naturally fall into two tribes, Chermesini and Phylloxerini, recognized by the number of joints to the antennæ. We have only a single genus to each of these tribes as represented in this country.

Genus PHYLLOXERA Fonscolombe, 1841.

Antennæ short, not more than one-third or one-fourth the length of the body; three-jointed, the first and second short and nearly equal, the third or terminal much the longest, imbricated, and with a large sensoria near the base and a much larger one near the apex. Eyes well developed in the winged insect, but small and rudimentary in some of the apterous. Beak moderately long, entirely wanting in the perfect sexes. Legs very short; tarsi one-jointed, furnished with two claws, two capitate bristles or long hairs, and with a cushion-like pad or pulvillus between the claws. Wings thin and delicate, large in proportion to the size of the body, folded horizontally when in repose; fore wings with a well marked subcostal and three oblique veins without any branching. The first and second of these oblique veins are sometimes united so that the second appear to be a branch of the first. Hind wings with a veinless subcostal. Honey-tubes wanting. The form of the body varies considerable, from globular in the early apterous form, to fusiform or ovate later on in the season. Most of the species form galls on plants, attacking not only the leaves but also the roots, as is the case with the well-known and so destructive grape Phylloxera both in this country and on the continent.

Only one species has been observed in Minnesota, but I doubt not that several will be found, especially on the leaves of the oak and hickory, here as elsewhere.

1. Phylloxera prolifera n. sp.

Apterous females. Color very pale lemon-yellow, smooth, convex above, especially in front, tapering behind into a rather long ovipositor. Eyes as a very small black spot. Antennæ short and fine, 3-jointed: I 0.05^{mm}, II 0.05^{mm}, III 0.10^{mm}. Beak short and thick, about 0.10^{mm}; the setæ very long when ex-

tended, at least as long as the body, brownish. Legs short; tarsi with two rather small claws, and with the two capitate hairs as usually in the genus.

Found in the galls of *Pemphigus populicaulis* Fitch during the fall after the pemphigiens have left or become destroyed. Usually but one female, or at most a few, was to be found in the gall together with a great number of pseudova in a pile that often would be several times the female in bulk. The pseudova are greenish-yellow when first laid, but soon become decidedly yellow before the larva frees himself from the covering. Their length is about 0.45^{mm}, and breadth 0.25^{mm}. I think this is the same species as mentioned by Prof. C. V. Riley as found in the galls of *Pemphigus populi-transversus* Riley,* which seems to take the place of the above named gall in the western and southern states. The insect was found not only in the galls fallen to the ground, as was the case by those observed by Prof. Riley, but more often in those still remaining on the tree. Time did not allow me to give any special attention to this interesting species, but I think it can nevertheless be recognized from the above short description on account of its peculiar habits. It is very probable that the early stages will not be found in connection with the galls, but on some other part of the tree, or even on some other tree, as migration from one tree to another appears not to be rare in the present genus.

Genus CHERMES Linnæus, 1748.

Antennæ short, stout, composed of five joints, the two first short, the third, fourth and fifth not much longer, and nearly sub-equal. Eyes conspicuous in winged form, sometimes wanting in the apterous. Beak short and stout; the setæ when extended are somtimes two or three times the length of the body Thorax much developed, especially the prothorax. Fore wings unusually broad; the costal rounded; the subcostal stout, ending with a broad stigma; the cubital wanting, but the long stigmal vein has the position and appearance of a cubital; two discoidals. Hind wings with but one discoidal. Legs short, tarsi with two claws. Honey-tubes wanting.

The species are not very numerous, and almost without exception confined to coniferous trees. The body is usually covered

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*See Bull. U. S. Geol. and Geogr. Surv. of the Terr., Vol. V., No. 1, p. 16.

by a flocculent exudation. No representative of this genus has yet been observed in Minnesota, but most of the species known will, without doubt, be found in the northern half of the state so rich in coniferous trees.

The following species belonging to the Chermesinæ have been recorded as American:—

Phylloxera vitifoliæ (Fitch). The grape Phylloxera.
Phylloxera castaniæ (Hald.). On the chestnut.
Phylloxera caryæcaulis (Fitch). On the hickory.
Phylloxera caryævenæ (Fitch). On the hickory.
Phylloxera caryæfoliæ Fitch. On the hickory.
Phylloxera caryæglobuli Walsh. On the hickory.
Phylloxera caryæsemen (Walsh). On the hickory.
Phylloxera caryæfallax Riley. On the hickory.
Phylloxera caryæglobosa (Shimer). On the hickory.
Phylloxera spinosa (Shimer). On the hickory.
Phylloxera caryæsepta (Shimer). On the hickory.
Phylloxera forcata (Shimer). On the hickory.
Phylloxera depressa (Shimer). On the hickory.
Phylloxera conica (Shimer). On the hickory.
Phylloxera caryægummosa Riley. On the hickory.
Phylloxera caryæren Riley. On the hickory.
Phylloxera rileyi Licht. On oak.
Chermes pinicorticis (Fitch). On pine.
Chermes laricifoliæ Fitch. Larix americana.
Chermes abieticolens (Thos.). On spruce.
Chermes abietis (Linn). On spruce.

Subfamily PEMPHIGINÆ.

Antennæ rather short; six-jointed, or rarely only five-jointed; the third joint the longest, the sixth usually coming next in length when the unguis or spur is counted. In some cases the third and following joints are annulated. Eyes large in the winged form; often wanting in the gall inhabiting apterous form. Beak moderately long, or wanting altogether in the true sexes. Thorax usually strongly arched above. Fore wings with the cubital simple, usually very hyaline or obsolete at base; the two discoidals often starting from the same point, or nearly so. Hind wings with two discoidals, except in Hormaphis, where there is but one. Legs short, tarsi with two claws and sometimes with a pair of capitate hairs as in Phylloxera. Honey-tubes wanting. Style inconspicuous or none.

This subfamily constitutes pre-eminently the gall making aphides, as most of them construct galls of peculiar shapes on various parts of woody plants, mostly trees.

The genera found in America may be recognized as follows:

1	Hind wings with two discoidals. - - - -	PEMPHIGUS.
	Hind wings with only one discoidal. - - - -	2.
2	Antennæ 6-jointed. - - - - -	TETRANEURA.
	Antennæ 5-jointed. - - - - -	HORMAPHIS.

Genus HORMAPHIS Osten-Sacken, 1861.

Antennæ five-jointed, first and second short, third the longest, fourth and fifth sub-equal; the three last joints strongly annulated. Eyes conspicuous. Beak moderately long. Front wings with the simple cubital obsolete at base; the two discoidals starting from the same point. Hind wings with a single discoidal, which is often very faint and almost obsolete. Legs moderately long; tarsi two-jointed, with two claws and a pair of long capitate bristles or hairs. Honey-tubes and style wanting.

Three species are now known, all from America, to which the genus appears to be peculiar. One, found on the witch-hazel (*Hamamelis virginica*), forms a gall on the leaves, and a second species on the same plant forms a gall by a deformation of the fruit-bud in autumn. A third species, described now, as I think, for the first time, forms no true gall, but finds a somewhat similar protection by corrugating the leaf under which it is found.

1. Hormaphis papyraceæ n. sp.

Antennæ nearly one-half the length of the body, about 0.60^{mm}, III 0.25^{mm}, IV 0.12^{mm}, V 0.13^{mm}, all the joints of nearly the same thickness; III with about twenty-five annulations, and the two last with about the same number together; the last joint with no apparent constriction or nail. Eyes dark brown. Beak rather short, appearing to rise from between the first pair of legs. Thorax very high, convex above, all black. Fore wings with cubital obsolete for nearly half its length; stigma long and narrow, pointed. Hind wings with two hooklets. Abdomen blackish, covered with a pulverulent and flocculent substance. Legs moderately long, black; tarsi two-jointed, with two claws and two superior capitate hairs. Honey-tubes and style wanting. Length of body 1.30^{mm}; to tip of wings 2.30^{mm}. Larvæ blackish, very flocculent, especially on the last segments.

Found on the under side of the leaves of birch (*Betula papyracea* Ait.), corrugating them between the veins, forming long folds, in which the lice are packed as close as it is possible for them to be and at the same time to reach the leaf with the beak. Being also abundantly covered by a flocculent substance, especially the apterous form, they find undoubtedly a good protection between these plications of the leaf. The first winged form was taken in the early part of June.

Genus PEMPHIGUS Hartig, 1841.

Antennæ moderately long, not more than half the length of the body, usually shorter; the third joint the longest, the sixth next in length, and always with a contraction or nail-like process at apex; sometimes annulated, but more commonly smooth or only with transverse sensoria, which sometimes give to the antennæ a very tuberculate and uneven surface. Eyes large in winged form, but often rudimentary or wanting in the apterous. Beak moderately long. Thorax much developed, arched above and with conspicuous lobes. Front wings with the cubital simple; the two discoidals arising from nearly the same point. Hind wings with two discoidals. Legs moderately long; tarsi two-jointed, and with two claws. Honey-tubes wanting. Style very small or none.

The species of this genus are more readily recognized from the peculiar galls that they produce than from any character that we can find in the insect. The species found in Minnesota may be separated as follows:

1. Unguis of the sixth joint longer than the joint; producing a large irregular gall on the end of twigs of the poplar. - - P. VAGABUNDUS.
   Unguis shorter than the joint. - - - - - - 2.
2. All the joints of the antennæ with transverse sensoria; size small; producing a smooth and regular gall on the leaf of sumach. - P. RHOIS.
   The last joint never with transverse sensoria; size larger. - - 3.
3. Cubital arising from the same point as the second discoidal; producing a pseudogall by curling the terminal leaves of ash. - P. FRAXINIFOLII.
   Cubital separate or obsolete at base. - - - - - 4.
4. Contraction of the sixth joint abrupt, the joint being thickest at the apex; producing a globular gall by the twisting of the petiole near the base of the leaf of the poplar, and hence with a broad and oblique opening. - - - - - - - - - P. POPULICAULIS.
   Contraction of the sixth joint gradual, the joint being thickest below the apex; producing an oval or globular gall on the petiole of the poplar with a small transverse opening. - - - P. POPULI-TRANSVERSUS.

1. Pemphigus populicaulis Fitch.

Pemphigus populicaulis Fitch. Ins. N. Y., 5th Report, § 353, 1859.
Byrsocrypta (*pemphigus*) *populicaulis* Walsh. Proc. Ent. Soc. Phil., Vol. I, p. 305, 1862.

Antennæ short, third joint with about six transverse sensoria, and the fourth with about half as many; the sixth joint is narrow at base gradully widening to the apex, where the contraction is abrupt, forming the short unguis; III 0.18^{mm}, IV 0.10^{mm}, V 0.10^{mm}, VI 0.18^{mm} with the unguis. Fore wings with the two discoidals arising close together, the third obsolete at base; stigma rather short and broad. Head and thorax black. Abdomen greenish, pulverulent. Expanse of wings about 6^{mm}.

The gall produced by this species is the globular swelling so often seen on the petiole near the base of the leaf of cottonwood (*Populus monilifera*). It is formed by the folding or twisting of the petiole, the edges coming together obliquely to the base of the leaf forming a broad opening or mouth.

2. Pemphigus populi-transversus Riley.

Pemphigus populi-transversus Riley. Bull. U. S. Geol. Surv. Terr., Vol. V, p. 15, 1879.

Antennæ similar to the foregoing species (*P. populicaulis*), but third and fourth joints with fewer transverse sensoria; the contraction of the sixth joint is more gradual, the joint being widest below the apex near the middle, and the unguis longer. Fore wings with the two discoidals arising close together; the cubital obsolete at base; stigma rather long and narrow. Expanse of wings 7^{mm}.

This species is slightly larger than the foregoing, but in other respects quite similar; like it also, pruinous, especially so in the apterous form. The gall is also similar in size and form, produced on the petiole near the base of the leaf of cottonwood (*Populus monilifera* and *balsamifera*). The swelling causes a curving of the petiole, and the mouth is a small opening transverse to the petiole or parallel to the base of the leaf.

3. Pemphigus vagabundus (Walsh).

Byrsocrypta vagabunda Walsh. Proc. Ent. Soc. Phil., Vol. I, p 306, 1862.

Pemphigus vagabundus Packard. Guide to the study of Ins., p. 524, 2d ed., 1870.

Antennæ about half as long as the body; third joint with 8–10 transverse sensoria, fourth with only a few; sixth joint, with the unguis, as long as the third; the unguis as long again as the sixth joint; III 0.30^{mm}, IV 0.10^{mm}, V 0.08^{mm}, VI 0.30^{mm}, of which the unguis measures at least 0.20^{mm}. Beak reaching second coxæ. Head and thorax black. Abdomen paler. Wings very hyaline, with thin and almost imperceptible veins except costal and subcostal which are slightly smoky; stigma rather narrow. Second discoidal originating near to the first. Length of body about 1.75^{mm}; expanse of wings about 7^{mm}.

The species described by Walsh as *vagabunda* is evidently something else from that producing the large irregular gall on the end of twigs of poplar to which the name *vagabunda* has also commonly been applied. It was first described from specimens taken on various forest trees without knowing the gall, and it was not till sometime afterwards that the connection was made between the two. Moreover the specimens described by Walsh were taken in September, when it has been supposed the winged insect made its appearance, but as I have found the galls empty and beginning to turn black already in August, it is evident that the species of this gall appears much earlier.

The galls are very common in and around Minneapolis, and I had hopes of making out the life history during the present season, but from my absence during the greater part of the season I was unable to do so. On my return in August I found all the galls deserted with only castings and occasionally a dead specimen. In one gall I thus found a great number of winged specimens from which I have given the above description. All the castings also agree with the same, and are so strongly characterized by the long unguis of the sixth joint that I have no doubt that this is the true species of the gall in question.

4. Pemphigus rhois (Fitch).

Byrsocrypta rhois Fitch. Month. Journ. N. Y. St. Ag. Soc., p. 73, Aug., 1866.
Melaphis rhois Walsh. Phil. Ent. Soc., Vol. VI., p. 281, Dec., 1866.
Pemphigus rhois Packard. Guide to the study of Ins., p. 524, 2d Ed., 1870.

Antennæ about half as long as the body; joints 3–6 with numerous transverse sensoria that almost encircle the joints; the unguis short but distinct; the normal six-jointed antenna measures on an average, III 0.12^{mm}, IV 0.10^{mm}, V 0.10^{mm}, VI 0.15^{mm}. Fore wings with the cubital obsolete at base; the two discoidals are not as close together at base as usual in this genus. Hind wings with the position of the veins normal; second discoidal obsolete at base. Length of body about 1^{mm}, to tip of wings $2\text{–}2.50^{mm}$.

A small species that makes a smooth, thin walled gall on the underside of the leaf of sumach (*Rhus glabra*) usually near the base of the leaf, varying from half an inch to an inch in diameter. It departs somewhat from a typical Pemphigus, and was made the type for a new genus by Walsh, though a variation in the number of joints alone will not warrant a separation in this case. The normal number of joints is six, but often some are found connate so as to be but five-jointed and more rarely only four-jointed.

5. Pemphigus fraxinifolii Riley.

Pemphigus fraxinifolii Riley. Bull. U. S. Geol. Sur. Terr., Vol. V., p. 17, 1879.
Pemphigus fraxinifolii Thomas. Ins. Ill., 8th report, p. 146 and 210, 1879.

Antennæ about half as long as the body; joints 3–5 with transverse sensoria, but less distinct than usual; III 0.25^{mm}, IV 0.12^{mm}, V 0.15^{mm}, VI 0.18^{mm} including the unguis of the usual length. Head and thorax dusky or black, abdomen dark green varying to yellowish green. Beak reaching second coxæ. Wings hyaline, with slender veins; the third discoidal subhyaline at base, arising from nearly the same point as the second discoidal; stigmal vein subobsolete at base, arising from the middle of the stigma, nearly straight. Hind wings with the two discoidals arising from the same point. Length of body 2^{mm}; to tip of wings 3^{mm}.

Found on the terminal leaves of ash (*Fraxinus americanus*) causing them to curl and form a pseudogall. The insects are much covered with a flocculent matter, and exude an abundant liquid as in *Schizoneura americana*, with which species it would appear to agree in habit.

The following species of Pemphiginæ have been recorded as American though not yet found in Minnesota:

Tetraneura ulmi (Linn), producing a small pedunculated gall on the leaves of elm.

Tetraneura graminis Monell, on the leaves of *Aira caespitosa* and *Agrostis plumosa*, enveloped in a cotton-like secretion. For a notice of these two species see the Can. Ent., Vol. XIV., p. 16.

Hormaphis hamamelidis (Fitch), producing a conical gall on the leaves of witch-hazel (*Hamamelis virginica*).

Hormaphis spinosus (Shimer), producing a gall on the stem of the same plant in autumn, being a deformation of the fruit bud.

Pemphigus tesselata (Fitch), found on the branches of alder (*Alnus rubra*).

Pemphigus imbricator (Fitch), a flocculent species found on the under side of the branches of beech (*Betula*).

Pemphigus popularia Fitch, the gall of which is not known; described from specimens found on trunk of poplar.

Pemphigus populi-globuli Fitch, producing a globular gall on the upper surface, near the base of the leaf of poplar (*Populus balsamifera*).

Pemphigus populi-venæ Fitch, producing an oblong compressed gall on the mid-vein of the leaves of poplar (*Populus balsamifera*).

Pemphigus pseudobyrsa Walsh, producing a smooth, semicircular, compressed gall near the mid-vein of the leaves of poplar (*Populus angulata*).

Pemphigus formicarius Walsh, and

Pemphigus formicetorum Walsh, found in the nest of ants.

Pemphigus ulmi-fusus (Walsh), producing a spindle-shaped gall on the upper surface of the leaves of red elm.

Pemphigus populi-monilis Riley, producing a series of small galls on the upper side of the leaf of the narrow-leaved cottonwood (*Populus balsamifera*).

Pemphigus populi ramulorum Riley, forming an irregular globular gall on the twigs of *Populus balsamifera*.

Pemphigus acerifolii Riley, a flocculent species on the under side of the leaves of *Acer dasycarpum*, causing them to curl.

Pemphigus aceris Monell, on the under side of limbs of hard maple, enveloped in wooly matter.

Pemphigus rubi Thomas, on the under side of the leaves of *Rubus occidentalis*, along the mid-vein.

Subfamily SCHIZONEURINÆ.

Antennæ short, not more than half the length of the body and mostly shorter, six-jointed, the last with a short spur; usually annulated and with transverse sensoria, or when not annulated with circular sensoria. Beak moderately long, wanting in some of the sexual forms. Fore wings with two discoidals usually arising from near to each other; the third or cubital with one branch, obsolete at base. Hind wings with one or two discoidals. Honey-tubes rudimentary or wanting. Style none.

Most of the species are found with a flocculent matter, though some are only pulverulent. A few produce galls as in the preceeding subfamily, but more commonly they only curl the leaves or are protected by their flocculent exudation. Several of the subterranean species belong here. Some aphidologists would include this subfamily with the Pemphiginæ, principally on account of similarity in habit and development, but I prefer with others to consider it as distinct.

The two genera found in America may be distinguished as follows:

Hind wings with two discoidals. - - - - - SCHIZONEURA.
Hind wings with only one discoidal. - - - - - COLOPHA.

Genus COLOPHA Monell, 1877.

Antennæ short, not reaching beyond the thorax, strongly annulated; third joint the longest and about as long as the three following. Beak short. Fore wings with the two discoidals arising from nearly the same point. Hind wings with only one discoidal. Honey-tubes and style wanting.

Only two species are known in this genus, and one of these forms a true gall on the elm. The oviparous female produces but one large egg in the fall.

1. Colopha ulmicola (Fitch).

Byrsocrypta ulmicola Fitch. Ins. N. Y., 4th Report, p. 63, § 347, 1858.

Thelaxes ulmicola Walsh. Proc. Ent. Soc. Phil., Vol. I., p. 305, 1862; American Entomologist, Vol. I., 1869.

Colopha ulmicola Monell. Can. Ent., Vol. IX., p. 102, 1877.

Glyphina ulmicola Thomas. Ins. Ill., 8th Rept., p. 142 and 204, 1879.
Colopha compressa Lichtenstein and other European authors; Monell, Can. Ent., Vol. XIV., p. 15, 1882.

Antennæ reaching to the insertions of the fore wings, strongly annulated; the third joint the longest, about as long as the three following joints. Fore wings with the cubital once branched, obsolete for some distance at base; the two discoidals close together at base. Hind wings with only one discoidal. Honey-tubes wanting. Expanse of wings 3-4^{mm}.

This species produces the well-known cock's-comb gall on the upper surface of the leaf of elm (*Ulmus americana*). Placed between two parallel branch veins of the leaf, the opening is always a long slit on the under side parallel with these veins. The gall above is about one inch long by one-fourth as high, compressed and with numerous perpendicular folds or wrinkles, the summit cut-toothed.

There has been great diversity of opinion in regard to the generic position of this species, as will be seen from the above synonyms. Some of the latest writers in Europe have considered Koch's compressa as identical with our ulmicola, which opinion I followed in my list of the family in the 14th annual report of the survey. But Mr. Monell, the author of the genus as now recognized, writes me: "I think our European friends have been a little hasty in calling compressa and ulmicola identical. I doubt it very much." As far as my own observations go, I think it is distinct.

Not observed to be as common here in Minnesota as further south.

Genus SCHIZONEURA Hartig, 1841.

Antennæ sometimes half as long as the body, but usually shorter; third joint the longest and often as long as the three following joints; annulated and then with transverse sensoria, or smooth when they are circular. Beak moderately long, but often reaching third pair of coxæ. Fore wings with cubital once branched, mostly obsolete for some distance at base; the two discoidals close together at base. Hind wings with two discoidals. Honey-tubes rudimentary or wanting.

Most of the species are covered with flocculent or wooly matter. In habit the genus shows a great diversity; some are found

on leaves with or without curling them, others on the twigs or limbs under cover of their wooly matter, not a few are subterranean on roots of grasses or trees, and Mr. Walsh describes one species as inhabiting the fungus.

The five species found in Minnesota may be recognized as follows:

1	Antennæ annulated; sensoria transverse.	2.
	Antennæ not annulated; sensoria circular.	3.
2	Cubital obsolete at base.	S. AMERICANA.
	Cubital not obsolete.	S. CRATÆGI.
3	Abdomen with a patch of velvety black above.	S. CORNI.
	Abdomen of uniform color.	4.
4	All black; aerial.	S. QUERCI.
	Abdomen greenish; subterranean.	S. PANICOLA.

1. Schizoneura americana Riley.

Schizoneura americana Riley. Bull. U. S. Geol.Surv. Terr., Vol. V., p. 4, 1879.

Head and thorax black; abdomen reddish brown. Antennæ reaching the abdomen; third joint the longest and longer than the three following; III 0.45^{mm}, IV 0.12^{mm}, V 0.13^{mm}, VI 0.10^{mm}; third fourth and fifth joints strongly annulated, there being about 22 annules to the third. Beak rather long. Cubital vein of fore wings obsolete for some distance at base, rarely tracable its whole length. Honey-tubes sub-obsolete, hardly above the surface of the abdomen.

Found on the under side of the leaves of elm (*Ulmus americana*) causing them to curl, forming a pseudogall. When very numerous they sometimes affect all the leaves at the end of a twig forming a mass, conspicuous on account of the sickly yellowish-color of all the leaves thus involved. Strongly pulverulent, and exuding an abundance of liquid that is found as small globules in the gall. Expanse of wings $5\text{-}6^{mm}$.

2. Schizoneura cratægi n. sp.

Head and thorax shining black; abdomen that is reddish-brown in the apterous form, becomes dusky or almost black in the winged. Antennæ similar to the preceding species but somewhat shorter; III 0.35^{mm}, IV 0.10^{mm}, V 0.12^{mm}, VI 0.10^{mm}. Beak reaching third coxæ, or abdomen. Wings hyaline, with slender veins; cubital of the fore wings can be distinctly traced

for its whole length though often very slender, branching from about midway of its length. In other respects the wings are similar to the foregoing species. Legs and tarsi somewhat shorter. Honey-tubes are circular openings but slightly raised above the surface of the abdomen. Expanse of wings 6^{mm}. The apterous forms are much covered with flocculent matter; the winged only pulverulent.

Found very numerous on the under side of the twigs of hawthorn (*Cratægus punctata*). One tree especially, observed during September, had almost a continuous row on the under side of every twig, and very conspicuous from the flocculent covering of the apterous form. Very similar to *Schizoneura americana* in size and general appearance, but distinct in habit and easily distinguished by a shorter antenna and the cubital not being obsolete at base.

This is evidently not *S. lanigera*, and I know of no other species as found on Cratægus or related plants, and have therefore described it as new.

3. Schizoneura corni (Fab).

Head and thorax black; abdomen reddish-brown, with a large patch of velvety black covering all of the dorsum except three of the first and some of the last segments. Antennæ reaching to end of thorax; not annulated, hairy, with a single row of circular sensoria on the under side, about six to the third joint, three to the fourth, two to the fifth, and one at the contraction of the sixth; III 0.30^{mm}, IV 0.12^{mm}, V 0.10^{mm}, VI 0.15^{mm}, with the short unguis. Beak reaching third coxæ. Wings hyaline, with slender veins; cubital obsolete at base; stigma broad and short, smoky. Honey-tubes a circular opening almost on a level with the abdomen. Expanse of wings 6–7^{mm}.

This species is very common in the fall during September and October. Found in great numbers on the under side of the leaves of Cornus, and also on the wing, when they are caught in great numbers in the webs of spiders. It agrees in all respects with the description and figure of *S. corni* Fab. as given by Buckton, and I have no doubt that our species is identical with the European. Walsh's *cornicola* is apparently something else.

4. Schizoneura querci (Fitch).

Eriosoma querci Fitch. Ins. N. Y., 5th Report, §306, 1859.
Schizoneura querci Thomas. Ins. Ill., 8th Report, p. 139, 1879.

What I presume to be this species I have taken on several occasions in the apterous form on oak, but I have never succeeded in finding or rearing the winged form. The apterous form is found with much flocculent matter, as common in this genus, and the antenna, as seen from the larva, is not annulated but smooth. I add Fitch's notes on the winged form:

"The winged individuals are black throughout, and slightly dusted over with an ash-gray powder resembling mould. The fore wings are clear and glassy, with their stigma-spot dusky and feebly transparent, their rib-vein black, and their third oblique vein abortive nearly or quite to the fork. It is 0.16 (inch) long to the tips of its wings."

5. Schizoneura panicola Thomas.

Schizoneura panicola Thomas. Ins. Ill., 8th Report, p. 138, 1879.

Head and thorax dusky or black; abdomen pale greenish with some black marking above, on the last segment at least. Antennæ reaching to the end of thorax, hairy, third joint the longest, the three following subequal; sensoria rather indistinct, three or four to the third joint, and usually one or two to each of the following. Beak reaching abdomen. Honey-tubes as circular openings on level with surface of abdomen, but rather conspicuous from being bordered with a ring of black. Wings hyaline, with slender but distinct veins. Fore wings with the cubital obsolete for some distance at base; stigma short and broad; stigmal vein but slightly curved near the base, straight. Expanse of wings about 5^{mm}.

Found on the roots of grasses; more commonly on *Panicum glabrum* also on *Setaria glauca* and *Eragrostis pectinacea spectabilis*. The winged form found during September.

American species of Schizoneurinæ not yet found in Minnesota are the following:

Colopha eragrostidis Middleton, found on *Eragrostis poæoides megastachya* and on some species of *Panicum*.

Schizoneura lanigera (Hausmann), the woolly aphis of the apple tree.*

*In 1880 Mr. Mendenhall read a paper before the Minnesota State Horticultural Society on plant lice, found in the annual report of the society for that year, in which he speaks of the

Schizoneura fungicola (Walsh). "Numerous individuals, unaccompanied by larvæ, occurred on a large, moist fungus a hundred yards from the nearest trees, which were all oaks." (Walsh.)

Schizoneura cornicola (Walsh), found on the under side of the leaves of red osier dogwood (*Cornus*).

Schizoneura rileyi Thomas, on the limbs and trunk of elm (*Ulmus americana*), causing a knotty growth of the wood.

Schizoneura pinicola Thomas, feeding at the base of the leaves of white pine, covered with a flocculent secretion.

Subfamily LACHNINÆ.

Antennæ moderately long, usually half the length of the body or a little longer, six-jointed, third the longest, sixth with a short spur or unguis as in the foregoing subfamily. Beak long, usually reaching to or beyond the third pair of coxæ, sometimes much longer than the body. Fore wings with the cubital twice forked; two discoidals. Hind wings with two discoidals. Legs long, especially the hind pair; tarsi two-jointed, provided with two strong claws. Honey-tubes very short and thick, tuberculate, sometimes reduced to a level with the surface of the body, and very inconspicuous. Style very short on none.

This subfamily is intermediate between the last and the next, principally partaking of the Pemphiginæ in the form of the antennæ, and of the Aphidinæ in the venation of the wings. But it is readily separated from either, and in habit is quite distinct. None of the species construct galls, or protection of any kind, as we find so often in the Pemphiginæ, but they are usually found on the limbs or the trunks of trees, and their only protection lies in their similarity in color with the branch or trunk on which they are found. In color they are therefore mostly dull gray, brown, or black. In size they are some of our largest aphides, often quite clumsy looking, with a small head and thorax but a very large and broad abdomen.

Only two genera are represented in America:

Stigmal vein straight, abdomen bare. - - - - - LACHNUS.

Stigmal vein curved, abdomen flocculent or woolly. - - PHYLLAPHIS.

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woolly apple tree louse and other species that are injurious to the horticulturist, but without stating if the species had been found in Minnesota or not. I hardly doubt that this species is already found in the state, as it is common south of us, and it is only from a want of opportunity to search for it where it is likely to be found that I do not add it to the list of Minnesota species.

In the same paper Mr. Mendenhall also speaks of *Pemphigus populi-monilis*, but as this species appears to be confined only to the narrow-leaved cottonwood (*Populus balsamifera angustifolia*), a species of poplar not found here, this one at least can hardly refer to Minnesota.

Genus LACHNUS Burmeister, 1835.

Antennæ usually about half as long as the body, six-jointed, the last joint with an unguis or spur at the tip, which is always shorter than the sixth. Beak very long, reaching to or beyond the third pair of coxæ, sometimes much longer. Fore wings with two discoidals, a twice branched cubital, and an almost straight stigmal vein; stigma unusually long. Hind wings with two discoidals. Legs very long, especially the hind pair, with long and two-jointed tarsi provided with two strong claws. Honey-tubes short, not longer than broad, often tuberculate or even wanting. Style inconspicuous or none.

Lachnus is the typical genus of the subfamily, with a rather small and narrow head and thorax, but a broad and clumsy abdomen, long and slender beak, very long legs. The body is nearly always covered with fine hairs, and sometimes also slightly pulverulent. Found mostly on branches of trees, but occasionally also on the leaves.

1. Lachnus laricifex Fitch.

Lachnus laricifex Fitch. Trans. N. Y. Agr. Soc., Vol. XVII, § 288, 1858.

Antennæ about reaching to the abdomen, dusky or black except at base; third joint the longest, as long as the fourth and fifth together; the last joint fusiform and shortest; III 0.50^{mm}, IV 0.23^{mm}, V 0.25^{mm}, VI 0.15^{mm}. Beak very long and slender, 1.40^{mm}, reaching beyond the third pair of coxæ; pale at base, more or less dusky at tip. Eyes black. Legs long and slender, with dusky or almost black femora; tibiæ pale, except at the apex, together with the tarsi, black; tarsi very long (about 0.30^{mm}, front pair), with two strong claws. Expanse of wings about 9^{mm}. Fore wings with a strong, robust, and dusky costal and subcostal, but the oblique veins are very thin. The two oblique discoidals being strongest and brownish; the cubital subhyaline, especially at base; the stigmal vein straight and appearing as a continuation of the subcostal, forming a marginal cell of about the same width as the stigma. Stigma very long, about one-third the length of the wings, of uniform width throughout, and truncate in front, in color rather dark brown. Hind wings with four hooklets. Honey-tubes short and thick, black. The winged insect is more or less black throughout, quite hairy,

especially the front of the head, the abdomen and the legs. The apterous form are brownish, or even grayish from being more or less pulverulent, especially on the under side, above with a longitudinal white line on the abdomen.

The apterous form was described by Dr. Fitch some thirty years ago, but the species appears not to have been observed by any of our entomologists since that time. The insect is not rare on the tamarack or American larch, *Larix americana*, but is quite difficult to find on account of its great similarity in color and shape to the irregularities of the twig on which it lives. It is generally located in the axils of the tufts of leaves, but when numerous can be found anywhere on the small twigs. It moves about with a very rapid and jerky motion when disturbed, reminding us of the Cicindela among the beetles, and thus easily escapes from observation unless you have well spotted the individual. The winged form first makes its appearance about the middle of May.

Several species of Lachninæ have been recorded as American, most of which will undoubtedly also be found in Minnesota.

Phyllaphis fagi (Linn.), found on the beach (*Fagus*).

Phyllaphis niger Ashmead, on oak (*Quercus phellos laurifolia*).

Lachnus viminalis (Fonsc.), on the limbs of willow. This is the same species as *L. dentatus* of Le Baron.

Lachnus caryæ (Harris), on the limbs of hickory (*Carya porcina*).

Lachnus strobi (Fitch), on white pine.

Lachnus abietis (Fitch), on *Abies nigra*.

Lachnus quercifoliæ Fitch, on the leaves of white oak.

Lachnus salicelis Fitch, on the twigs of willow. This is probably a Melanoxanthus or Chaitophorus.

Lachnus alnifoliæ Fitch, on leaves of alder.

Lachnus longistigma Monell, on linden (*Tilia americana*).

Lachnus quercicolens Ashmead, on oak.

Lachnus australe Ashmead, on pine.

Lachnus platanicola Riley, on sycamore trees.

Subfamily APHIDINÆ.

Antennæ 7-jointed, never very short, often much longer than the body. Eyes always present, and with a distinct tubercle. Beak variable in length, but seldom very long. Fore wings with two discoidals, a twice forked cubital, and more or less curved stigmal vein. Hind wings with two discoidals. Legs usually of moderate length; tarsi two-jointed, and with two claws (except the anomalous *Mastopoda*). Honey-tubes of variable length, but mostly longer than broad, or very rarely none. Style present and mostly very conspicuous.

This is by far the largest subfamily, and it more than outnumbers all the others put together. The characters are somewhat variable, making it much more difficult to define than any of the preceding. One of the most easily observed character is undoubtedly the so-called seventh joint of the antennæ, which, as has been stated by several writers, is but a contracted prolongation of the sixth, but as it here takes on the character of a separate joint, being nearly always longer than the sixth, and often as long or longer than the third, it is convenient to consider it as such. In some of *Callipterini* it becomes so reduced in length as to be difficult to distinguish from the unguis, and we have, therefore, to rely on other characters.

A great many of the species are found on herbs or annual plants, some are confined to the foliage of trees, or more rarely to the twigs, and a few have a subterranean habit. They are mostly found on the under side of the leaves, or, more rarely, on the stem of the plant they inhabit, and never construct a true gall; but a few of the genus *Aphis* curl the leaves, and so form what is known as a pseudogall. The body is usually smooth, sometimes pulverulent, but never with the flocculent substance found in the lower subfamilies. In development they are the typical aphides.

The subfamily may be divided into the three following tribes:

1. Style long, at least as long as the tarsus of the first pair of legs; antennæ on conspicuous frontal tubercles. - - - - NECTAROPHORINI.
   Style short or none, hardly ever longer than the tarsus; antennæ on no frontal tubercles, or on very short ones. - - - - - 2.

2. Style conical; honey-tubes moderately long, cylindrical or rarely incrassate. - - - - - - - - - - APHIDINI.
   Style very short or none, globular or knobbed; honey-tubes short, not longer than broad, or if longer they still show a strong incrassate character. - - - - - - - - CALLIPTERINI.

TRIBE CALLIPTERINI.

Antennæ variable in length, in the typical genera as long or longer than the body; in those where they are shorter, more or less hirsute; on no frontal tubercles, except in *Drepanosiphum;* seven-jointed, and the last joint, with few exceptions, as long or longer than the sixth. Beak very short except in Melanoxanthus. Wings normal, sometimes clouded by dusky markings or bands. Abdomen often tuberculate and hairy. Honey-tubes very short and tuberculate, not longer than thick, or when longer they still show a strong incrassate character; rarely obsolete. Style very short or none, usually rounded or globular at tip.

The genera here collected into a tribe have hitherto been disposed of otherwise, some being even classified with the *Lachninæ.* But they all show strong relationship, and have characters by which they can be readily distinguished from the two remaining tribes. In form they are some of our most elegant aphides; usually with an elongate and somewhat flattened body. In habit they are also quite uniform and distinct. If necessary the tribe could again be divided with Chaitophorus as type for those nearest to Lachninæ, as seen from the shortened antennæ and hirsute body; and Callipterus as type for the remaining genera as typical Aphidinæ.

The genera found in Minnesota may be separated as follows:

1	Antennæ nearly as long, and sometimes much longer than the body; never hairy.	2.
	Antennæ always shorter than the body and hairy.	4.
2	Wings held horizontal in repose.	MONELLIA.
	Wings deflexed in repose.	3.
3	Honey-tubes longer than broad, enlarged near the base; style very inconspicuous or none.	DREPANOSIPHUM.
	Honey-tubes short, tuberculate, sometimes obsolete; style short, globular.	CALLIPTERUS.
4	Beak short; honey-tubes tuberculate.	CHAITOPHORUS.
	Beak long; honey-tubes moderately long, and vasiform.	MELANOXANTHUS.

Genus MELANOXANTHUS Buckton, 1877.

Antennæ about one-half as long as the body, hairy as in Chaitophorus; seventh joint as long as the sixth, or usually longer. Beak long, reaching third pair of coxæ. Prothorax with a lateral tubercle. Legs normal, hairy. Wings with well defined veins. Honey-tubes short and stout, but always longer than broad, vasiform or broadest in the middle. Style very short and broad, or none.

Mr. Buckton, who has first given us a description of the genus, places it between Rhopalosiphum and Siphocoryne, but a more natural position is undoubtedly, as has been suggested to me by Mr. Monell, in the vicinity of Chaitophorus. I would consider it as connecting the Aphidinæ with the Lachninæ; having the venation of the former together with the antennæ, but in general form, together with some minor characters, and especially in habit, allies it to the latter. Its relationship to Chaitophorus is especially seen in the antennæ and honey-tubes.

Wings with robust and conspicuous veins, which are somewhat smoky along the sides. - - - - - - - - M. SALICIS.
Wings with their veins not smoky. - - - - - M. BICOLOR.

1. Melanoxanthus salicis (Linn.).

Aphis salicis Linn. Syst. Natura, 1761.
Melanoxanthus salicis Buckton. Mon. Brit. Aphid., Vol. II., p. 21, 1879.
? *Chaitophorus smithiæ* Monell. Bull. U. S. Geol. Surv. Terr., Vol. V., No. 1, p. 32, 1879.

Antennæ about half as long as the body, blackish except at base, with very long and spreading hairs; III 0.60^{mm}, IV 0.35^{mm}, V 0.30^{mm}, VI 0.20^{mm}, VII 0.15^{mm}. Beak long, 0.90^{mm}, reaching to or beyond third pair of coxæ. Prothorax with a blunt tubercle on each side; lobes all black. Legs yellowish, with black tibial points and tarsi. Wings with thick veins, slightly smoky along each side, especially the first discoidal, so as to be quite conspicuous. Abdomen with a grayish medial line and markings of the same color along each side. Honey-tubes vasiform, contracted at base, enlarging to at least twice the width in the middle, and again contracting at apex, twice the length of the tarsi in the winged form, in the apterous somewhat shorter; in

color a bright orange, often a decided reddish, contrasting much with the darker colors of the abdomen. Style not well defined. Length of body 3.00–3.75^{mm}; to tip of wings 5.50^{mm}. The males are much smaller in body, but with fully as large wings and antennæ as the females. The apterous form are also of a very large size, long oval, and with markings and color as above.

This very large and conspicuous species is by no means rare on the branches of willows, and occasionally also found on the poplar. In my list of the Aphididæ, in the last annual report of the survey, I refer to it as *Lachnus salicicola* Uhler, which is, as I now learn from specimens kindly furnished me by Mr. Monell, a very similar species, belonging to the genus under consideration. At the time I was unacquainted with Buckton's Monograph, and was led to consider it as a *Lachnus*, and as identical with Uhler's species from the writings of Doctor Thomas. *Lachnus salicicola* Uhler, or more correctly *Melanoxanthus salicti* Harris, as Harris' name is not occupied when applied to this genus, is a species of the eastern states, not yet found as far west as in Minnesota.

2. Melanoxanthus bicolor n. sp.

Antennæ somewhat longer and more slender than in the foregoing species; last joint always much longer than the sixth; III 0.65^{mm}, IV 0.35^{mm}, V 0.35^{mm}, VI 0.15^{mm}, VII 0.30^{mm}. In the winged males the relative length of the joints are somewhat more, also more thickly covered with small, round sensoria. Beak long, 0.85^{mm}, reaching to or beyond third pair of coxæ. Prothorax with lateral tubercles; lobes of thorax proper all black except the scutel, which usually has the reddish-brown color of the body. Legs brownish-yellow, with dusky tibial points and tarsi. Wings clear, with much thinner veins than in the foregoing, not bordered by any duskiness. Abdomen reddish-brown, with a medial line of paler color. Honey-tubes rather pale yellow, about twice the length of the tarsi (0.35^{mm}), vasiform, or in shape similar to the foregoing species. Style short, as broad as long, hairy, in color blackish, as well as the anal plates. Length of body 3.75^{mm}.

This species is quite distinct from the foregoing, though found on the same tree, and similar in habit. The body is elongate, conforming more with the typical *Callipterini;* the predominat-

ing color brown, and not with the grayish-white medial line; honey-tubes paler in color; the wings clearer and with more slender discoidal veins.

Genus CHAITOPHORUS Koch, 1854.

Antennæ mostly a little more than half the length of the body, hairy, last joint always as long or longer than the sixth. Beak short, but sometimes reaching second pair of coxæ or slightly beyond. Prothorax with no lateral tubercles. Wings much as in Aphis, but sometimes with smoky bands or spots. Legs moderately long, hairy. Abdomen usually tuberculate, and with long slender hairs, but which are never knobbed, even in the apterous form, as is so often the case in Callipterus. Honey-tubes short and thick; seldom longer than thick at base, rarely subobsolete. Style tubercle-like.

In general form the species of this genus have an elongate body, as in Callipterus, with which it shows many points of similarity; but will be recognized from the shorter antennæ and legs, together with the long spreading hairs of the antennæ and the whole body.

1	Abdomen with black dorsal spines in addition to the usual hairs of the body.	C. SPINOSUS.
	Abdomen with no dorsal spines.	2.
2	Wings with a smoky border along the veins.	C. POPULICOLA.
	Wings clear.	3.
3	Stigma long and narrow.	C. NEGUNDINIS.
	Stigma short and broad.	4.
4	Abdomen with transverse bands of brownish-black.	C. POPULIFOLIÆ.
	Abdomen of uniform black, or greenish-black.	C. NIGRÆ.

1. Chaitophorus negundinis Thos.

Chaitophorus negundinis Thomas. Bull. Ill. St. Lab. Nat. Hist., No. 2, p. 10, 1878.

Antennæ about as long as the body, paler at base, rest dusky, with long spreading hairs; III 0.40^{mm}, IV 0.30^{mm}, V 0.25^{mm}, VI 0.10^{mm}, VII 0.25^{mm}; the relative length of the joints varies somewhat, especially the third. Beak moderately long, reaching second pair of coxæ. Thorax with lobes black; prothorax green, or only dusky. Wings very thin and hyaline, with very narrow veins, except the costal and subcostal; stigma long and

narrow, pointed in front. Legs pale, with dusky tips, hairy. Abdomen green, often with a paler medial and marginal line, Honey-tubes short, about as long as thick at base, concolorous with abdomen. Style very short and truncate. Length of body about 2^{mm}; expanse of wings 6^{mm}.

The whole insect is very hirsute, especially the apterous form. Found on the under side of the leaves of box-elder, *Negundo aceroides* Mœnch., and when numerous can be found almost everywhere on the leaf, leafstalk and younger twigs. In early spring, even before the leaves are yet out, the newly hatched larvæ can often be seen crowding around the buds.

2. Chaitophorus spinosus Oestl.

Chaitophorus spinosus Oestlund. List Aph. Minn., p. 49, 1886.

Apterous form: Antennæ about one-half the length of the body, the basal joints pale except at apex, the two last all black; III 0.40^{mm}, IV 0.30^{mm}, V 0.28^{mm}, VI 0.08^{mm}, VII 0.08^{mm}. Beak hardly reaching second pair of coxæ. Abdomen yellow, with green dorsal markings, and with transverse rows of black spine-like hairs, which are also found on the head and thorax, together with the ordinary long white hairs of the genus. Honey-tubes typical, concolorous with the abdomen. Length of body $2–2.50^{mm}$, (exclusive of the ovipositor).

In the oviparous female, found during the fall, the tip of the abdomen is drawn out into a very long ovipositor, which is very conspicuous, as it becomes brownish-red with age. These females, at the time of ovipositing, descend to the woody part of the tree, securely depositing their stock of eggs in the crevices and between the bark. The species feeds on the leaves of the oak, and, as far as I have observed, is found only on the upper branches. The black spine-like hairs of the body will distinguish it from all other species of this genus. The winged form has not yet been observed.

3. Chaitophorus populifoliæ (Fitch).

Aphis populifoliæ Fitch. Cat. Hom. N. Y. St. Cab., p. 66, 1851.

Antennæ about two-thirds of the body in length, not as hairy as usual in the genus; third with numerous sensoria, fourth with a row of 4–6 larger ones, the seventh imbricated; III 0.35^{mm}, IV 0.22^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.25^{mm}. Beak short,

reaching second pair of coxæ. Thorax all black. Wings hyaline, as in *negundinis*, with slender brownish veins; stigma short and broad, dusky. Abdomen greenish, with a marginal row of blackish spots, and transverse bands of the same color above, often running together into a large quadrate patch. Honey-tubes as usual, slightly dusky. Style short and rounded. Length of body 1.60^{mm}; to tip of wings 3^{mm}.

Found on the under side of the leaves of *Populus grandidentata* Mx. It is with some doubt that I consider it as synonymous with Dr. Fitch's *Aphis populifoliæ*, found on the same tree, as the above description differs in several respects from Dr. Fitch's short description. The dorsal bands of all the species I have examined do not show any division in the middle, as appears to have been the case with Fitch's species. The antennæ are hardly hairy, but in other respects it is undoubtedly a Chaitophorus. It is quite similar to *negundinis*, but will be distinguished from this species by the short and broad stigma.

It remains to be ascertained if this species is not identical with *Chaitophorus populi* (Linn.), the two are at least very closely related.

4. Chaitophorus populicola Thos.

Chaitophorus populicola Thomas. Bull. Ill. St. Lab. Nat. Hist., No. 2, p. 10, 1878.

Antennæ about two-thirds of the body in length, very hairy; third and fourth joints with numerous small sensoria; III 0.35^{mm}, IV 0.20^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.15 to 0.20^{mm}. Beak stout, reaching middle pair of coxæ (0.40^{mm}). Thorax shining black, as well as prothorax; membrane yellowish. Wings with rather stout brownish veins; the discoidals with a smoky border on each side, expanding somewhat at the end of each vein; stigma smoky; hind wings more clear. Legs hairy, dusky or black. Abdomen greenish-yellow, with some transverse bands of black above. Honey-tubes paler than the abdomen, sometimes yellowish, about half as long as the tarsi. Style short, inconspicuous. Length of body 1.50–2^{mm}.

Apterous form reddish-brown, with a large Y-shaped yellowish spot on the abdomen. Found on the leaves of *Populus monilifera* Ait., and well distinguished from the other species by the smoky border along the veins of the wings.

5. Chaitophorus nigræ Oestl.

Chaitophorus nigræ Oestlund. List Minn. Aph., p. 49, 1886.

Antennæ nearly as long as the body, hairy; III 0.30^{mm}, IV 0.15^{mm}, V 0.12^{mm}, VI 0.08^{mm}, VII 0.20^{mm}. Beak short, not reaching second pair of coxæ (0.25^{mm}). Thorax all black. Legs more or less dusky, with black tarsi. Wings with slender brownish veins; stigma rather short and broad, brownish as the veins. Abdomen somewhat greenish, but mostly quite black. Honey-tubes not longer than thick, usually a little paler. Style globular. Length of body 1.50^{mm}. Apterous form varying from green to black. Found on the leaves of *Salix nigra* Marsh., as well as other species of willow. A small, blackish, hairy, aphis-like species, not as well characterized as the other species we have.

The following species have not yet been found in Minnesota:

Chaitophorus aceris (Linn.), on *Acer pennsylvanicum* if Dr. Fitch is correct in his identification.

Chaitophorus viminalis Monell, on young twigs and leaves of *Salix lucida* and *S. babylonica.*

Chaitophorus quercicola Monell, on the under side of the leaf of oak, *Quercus prinus.*

Chaitophorus flavus Forbes, on cultivated corn.

Chaitophorus pinicolens (Fitch), on pine. This is Dr. Fitch's *Aphis pinicolens*, which is believed to be a Chaitophorus.

Genus CALLIPTERUS Koch, 1855.

Antennæ usually about as long as the body, or sometimes much longer, smooth; transition from the sixth joint to the seventh gradual; the sensoria of the third in a single row, rather large, but usually on a level with the joint and difficult to trace. Eyes pale or bright red in color. Beak very short, rarely reaching the second pair of coxæ. Wings deflexed in repose, often with clouded spots or bands; front wings with the stigma short and much curved, often subhyaline. Honey-tubes short, sometimes almost on a level with the abdomen. Style short, enlarged at apex.

Some of our most elegant aphides, with an elongate, slender, and more or less depressed body, and of very pale and delicate colors. Sporadic in habit. Nearest to Chaitophorus in general appearance, but with much longer and smoother antennæ. The apterous form with long, slender and capitate hairs on the body, and usually of a pale yellow or whitish color.

The following species have been observed in Minnesota:

1	Dorsum of winged form with tubercles. - -	C. ULMIFOLII.
	Dorsum without tubercles. - - - - - -	2.
2	Marginal cell dusky. - - - - - -	C. BELLUS.
	Marginal cell hyaline. - - - - - - - -	3.
3	Wings with shaded spots, arranged somewhat in transverse bands.	4.
	Wings hyaline; the discoidal margined with black, often expanding at tip. - - - - - - - -	C. BETULÆCOLENS.
4	Abdomen with conspicuous transverse spots or bands; seventh joint of antennæ longer than the sixth. - - - - -	C. DISCOLOR.
	Abdomen with faint transverse bands, or none; seventh joint equal or nearly so to the sixth. - - - - - -	C. ASCLEPIADIS.

1. Callipterus discolor Monell.

Callipterus discolor Monell. U. S. Geol. Surv. Terr., Vol. V., No. 1, p. 30, 1879.
Myzocallis bella Thomas. Ins. Ill., 8th Rept., p. 108, 1879.

Antennæ about as long as the body, pale, with tips of joints 3-6 dusky; the single row of rather large sensoria on the third not always apparent; III 0.45^{mm}, IV 0.30^{mm}, V 0.25^{mm}, VI 0.12^{mm}, VII 0.20^{mm}. Head pointed in front. Eyes pale red. Beak very short. Thorax with a dusky band on either side. Legs pale, with dusky tarsi. Wings with irregular dusky spots, arranged somewhat in two oblique bands, which become especially apparent when the insect is seen from above with closed wings; veins ending in a smoky patch; second discoidal sinuous; stigma rather short. Veins of hind wings very sinuous. Abdomen yellowish, with four rows of black patches, which often are more or less confluent. Honey-tubes short, pale. Length of body $1.50-1.80^{mm}$.

Found on the leaves of *Quercus macrocarpa* Mx. The winged females found in the early part of the season are much smaller than those found further on. Mr. Monell gives the seventh joint of the antennæ as shorter than the sixth, but in normal specimens it is evidently longer.

Dr. Thomas' description of *Myzocallis bella* I think will agree better with the species under consideration than with Walsh's *Aphis bella*, with which he has confounded it.

The apterous form yellowish, and with long capitate hairs.

2. Callipterus asclepiadis Monell.

Callipterus asclepiadis Monell. Bull. U. S. Geol. Surv. Terr., Vol. V., No. 1, p. 29, 1879.

Antennæ about as long as the body, pale, tips of joints 3–6 black; the seventh joint of about the same length as the sixth; III 0.35^{mm}, IV 0.25^{mm}, V 0.20^{mm}, VI 0.10^{mm}, VII 0.10^{mm}. Beak a little longer than usual in the genus, reaching second pair of coxæ. Thorax with a marginal band on either side, as in foregoing species. Wings very much as in *C. discolor*, but usually not as distinctly marked. Abdomen yellowish, with longitudinal rows of dusky patches. Honey-tubes very short, yellowish. Length of body 1.50^{mm}.

Found on the underside of the leaves of *Asclepias cornuti* Linn. The apterous form are almost uniformly yellow or whitish, with long capitate hairs, easily distinguished from those of *C. discolor*.

3. Callipterus ulmifolii Monell.

Callipterus ulmifolii Monell. Bull. U. S. Geol. Surv. Terr., Vol. V., No. 1, p. 29, 1879.
Callipterus ulmicola Thomas. Ins. Ill., 8th Rept., p. 111, 1879.

Antennæ about as long as the body, pale, with the tips of joints 3–5 black; seventh joint about as long as the sixth; III 0.50^{mm}, IV 0.30^{mm}, V 0.25^{mm}, VI 0.12^{mm}, VII 0.12^{mm}. Eyes pale red. Beak short. Head and thorax usually with longitudinal lines of pulverulent. Wings thin and delicate; the second discoidal hardly at all sinuous; the subcostal curves in near the base of the stigma; stigma short and broad, dusky at both ends. Abdomen with four mammiform tubercules above on the basal segments, the other segments with various shorter tubercles; also with some pulverulent lines or dots, as on the head and thorax. Honey-tubes very short, concolorous with abdomen. Length of body $1.50–1.80^{mm}$.

This delicate species is found on the under side of the leaves of *Ulmus americana* Linn., and is easily distinguished from our other species on account of the tubercles of the abdomen.

4. Callipterus betulæcolens (Fitch.).

Aphis betulæcolens Fitch. Cat. Hom. N. Y. St. Cab., p. 66, 1851.
Callipterus betulæcolens Monell. Bull. U. S. Geol. Serv. Terr., Vol. V., p. 29, 1879.

Antennæ much longer than the body, sometimes nearly twice its length; first joint twice as long and large as the second; joints 3–6 white at base, with the apical half black; the seventh twice as long as the sixth, all black; the third joint with a single row of rather large sensoria; III 1.20^{mm}, IV 0.80^{mm}, V 0.65^{mm}, VI 0.30^{mm}, VII 0.70^{mm}; or the average of the smaller species: III 1.00^{mm}, IV 0.50^{mm}. V 0.45^{mm}, VI 0.20^{mm}, VII 0.40^{mm}. Eyes darker than usual in the genus. Beak also somewhat longer than usual, nearly reaching the second pair of coxæ. Legs nearly all black. Wings hyaline, with a rather pale and slender costal and subcostal; the first discoidal black, margined with dusky, and the most conspicuous vein; the other discoidals also slightly margined, as is apparent at least from the smoky patch at the tip of each vein; the stigmal vein often subobsolete for more than one-half of its length; stigma pale, except a smoky patch at each end, about as long again as broad. Honey-tubes concolorous with the abdomen, nearly as long as the tarsi. Length of body 2–2.50^{mm}; to tip of wings 4–4.50^{mm}.

This large species reminds us, in more than one respect, of Nectarophora, and differs somewhat from the typical Callipterus. It is found here on the under side of the leaves of *Betula papyracia* Ait., and varies considerable both in size and color, being found from a bright yellow to a bluish green. It is evidently distinct, though similar, to the European species found on the same tree.

5. Callipterus bellus (Walsh).

Aphis bella Walsh. Proc. Ent. Soc. Phil., Vol. I, p. 299, 1862.
Callipterus bella Monell. Bull. U. S. Geol. Surv. Terr., Vol. V, No. 1, p. 29, 1879.
Callipterus walshii Monell, l. c.
Myzocallis bella Thomas. Ins. Ill., 8th Rept., p. 106, 1879.

Antennæ not quite as long as the body, pale, with tips of joints 3–6 black; the sensoria of the third joints not very distinct; III 0.45^{mm}, IV 0.30^{mm}, V 0.25^{mm}, VI 0.15^{mm}, VII 0.25^{mm}. Eyes pale red (not black, as Walsh has it). Beak short. Pro-

thorax quite large; thorax with a broad marginal band of black, extending from the eyes to the base of the wings. Wings hyaline, with the costal and subcostal, as well as the space between, of a dark brown or black, including the stigma. A smoky-brown continuation of this band runs through the stigmal cell to the apex of the wing. The discoidals all slender; the stigmal vein short, sharply curved, forming a cell not broader than the stigma, and is altogether within the marginal band. Honey-tubes very short and conspicuous. Length of body about 2^{mm}; to tip of wings 3.50^{mm}.

Found on the under side of the leaves of red oak, *Quercus rubra* Linn. I do not think that *C. walshii* is distinct, though a smaller variety. Dr. Thomas appears not to have seen this species, as his own description of *Myzocallis bella*, which he thinks the same as Walsh's species, is evidently *C. discolor*. The insect is well characterized by the black margin of the head and thorax, and the continuation of this band along the whole length of the wing. It comes nearer to the following genus than any of the other species, and may be considered as connecting the two.

Species described as American, but not yet found in Minnesota are the following:

Callipterus mucidus Fitch, a doubtful species.
Callipterus castaneæ Fitch, on the under side of the leaves of chestnut.
Callipterus punctatus Monell, on the under side of the leaves of *Quercus bicolor*.
Callipterus hyalinus Monell, on the under side of leaves of *Quercus imbricaria*.
Callipterus caryæ Monell, on leaves of walnut, hickory and pecan.
Callipterus quercicola Monell, on oak.
Callipterus trifolii Monell, on clover leaves.

Genus MONELLIA n. g.

Antennæ longer than the body, on no frontal tubercles. Eyes pale red; ocelli present. Beak very short. Thorax low and flat; prothorax nearly as large as thorax proper. Wings held horizontal in repose; venation as in Callipterus. Honey-tubes not obvious. Style short, enlarged at apex.

Small and delicate insects of very pale color and a strongly depressed body. Distinguished from the foregoing genus by the horizontal position of the wings when at rest, and by the much developed prothorax. In habits similar to Drepanosiphum, and like it, the oiviparous female appears always to acquire wings

before producing living young. The genus is named in honor of Mr. Monell, who has done so much towards our knowledge of the Aphididæ of North America, and especially in the genus Callipterus.

1. Monellia caryella (Fitch).

Aphis caryella Fitch. Trans. N. Y. St. Agr. Soc., Vol. XIV, or Ins. of N. Y., Vol. 1, p. 165, 1855.
Aphis punctatella Fitch. l. c., p. 165.
Aphis maculella Fitch. l. c., p. 166.
Aphis fumipennella Fitch. l. c., p. 166.
Aphis marginella Fitch. l. c., p. 166.
Callipterus caryellus Fitch. Trans. N. Y. St. Agr. Soc., Vol. XVI., or Ins. of N. Y., Vol. II, § 167, 1856.
Callipterus punctatellus Fitch. l. c., § 168.
Callipterus maculellus Fitch. l. c., § 169.
Callipterus fumipennellus Fitch. l. c., § 170.
Callipterus marginellus Fitch. l. c., § 171.

Antennæ longer than the body, the first and second, together with the base of the third, dusky or black, the remaining joints pale at base becoming dusky or black at tip. Sensoria of the third joint all close together on the basal half, which is also somewhat thickened. The relative length of the joints varies considerably in this variable species, but the most constant measurement appears to be: III 0.40^{mm}, IV 0.30^{mm}, V 0.28^{mm}, VI 0.20^{mm}, VI 0.15^{mm}. Beak very short. Eyes bright red. Thorax low and depressed; prothorax very large, as large as the thorax proper, often with a marginal band of black as seen in *Callipterus bellus.* Wings hyaline, iridescent, folded horizontally close to the body in repose. In full colored specimens a band of dark brown or black is often seen along the upper margin of the fore wings, including the costal and subcostal. Stigma short, regularly curved, often subobsolete. Honey-tubes not apparent. Length of body $1.50-2^{mm}$; color of body pale yellow or whitish.

This interesting species is found on the under side of the leaves of *Carya amara* Nutt, along the mid-vein; usually but one, or at the most, a few, are found on the same leaf. On being disturbed they are capable of jumping to a considerable distance, a fact, though, not confined to this species, but observed in several of this tribe. The species appears not to have been

observed since it was first described by Dr. Fitch, and much uncertainty has therefore been in regard to its position. I do not hesitate to consider the four species described by Dr. Fitch in connection with his *Aphis caryella*, as only varieties, as often two or three of them are seen on the same leaf, and transitional forms have been observed between most of them. In my list of the Aphididæ of Minnesota, in the fourteenth annual report of the survey, I give *Callipterus caryæ* Monell as a species for Minnesota, based on the observation of a few wingless specimens, which I now do not doubt belong to the one under consideration, and *C. caryæ* should therefore be dropped from the list.

Genus DREPANOSIPHUM Koch, 1887.

Antennæ fixed on frontal tubercles, longer than the body; the setaceous seventh longer or as long as the third; third joint with a single row of rather large sensoria. Eyes bright red. Beak short. Wings long and narrow; marginal cell elongated towards the apex. Honey-tubes moderately long in our species, but much longer in some of the foreign, enlarged towards the base. Style inconspicuous or none.

A well characterized genus, which by some writers has been put in Nectarophora, or near to it; but a more natural position is without doubt in connection with Callipterus, as has been pointed out by Mr. Monell.

1. Drepanosiphum acerifolii (Thomas).

Siphonophora acerifoliæ Thomas. Bull. Ill. St. Lab. Nat. Hist., No. 2, p. 4, 1878.

Drepanosiphum acerifolii Monell. Bull. U. S. Geol. Surv. Terr., Vol. V., No. 1, p. 27, 1879.

Antennæ much longer than the body, pale, with tips of joint 3–6 dusky, third joint with a single row of sensoria on the basal half, slightly raised above the surface; setaceous seventh very long, often much longer than the third; III 0.80^{mm}, IV 0.65^{mm}, V 0.60^{mm}, VI 0.15^{mm}, VII 0.85^{mm}, or sometimes over 1^{mm}. Wings hyaline, with slender veins; veins sometimes slightly dusky along the margins, expanding into a patch at tip; stigma short and broad. Abdomen with several rather large tubercles on the basal segments above, each tipped with a short stiff hair.

Honey-tubes slightly longer than the tarsi, enlarged towards the base. Length of body 1.50–2^{mm}; to tip of wings about 3.50^{mm}.

Found, mostly solitary, on the underside of the leaves of *Acer dasycarpum* Ehrh. A very beautiful species of a light gray color and with longitudinal lines of pure white above, which are often broken into dots.

TRIBE APHIDINI.

Antennæ moderately long, nearly always a little shorter than the body; on no frontal tubercles, or on very inconspicuous ones. Seven-jointed (except in *Mastopoda*); the seventh joint always longer than the sixth. Eyes dark brown or black. Beak, moderately long, never very short. Legs moderately long and stout. Abdomen usually short, obtuse or rounded behind. Honey-tubes moderately long, rarely very short or wanting, cylindrical or slightly incrassate in a few cases. Style moderately long, stout, conical, very rarely none.

While the Nectarophorini are characterized by a long and cylindrical body, the Callipterini by a long and flat, the present tribe mostly presents us with a short and compact form. The appendages are nearly always of a moderate length. The presence or absence of frontal tubercules is not sufficient to separate the present tribe from the following, as in fact no one character taken by itself will, as the two tribes run a great deal into each other in this respect.

They are found in large colonies on herbaceous plants or on the leaves of woody plants, and in a few cases also on roots. The following genera are represented in Minnesota:

1	Antennæ 7-jointed; tarsi normal.	2.
	Antennæ 6-jointed; tarsi atrophied.	MASTOPODA.
2	Honey-tubes clavate.	SIPHOCORYNE.
	Honey-tubes cylindrical, rarely incrassate or none.	3.
3	Body long and somewhat depressed; honey-tubes short, not longer than style.	HYALOPTERUS.
	Body short and thick; honey-tubes moderately long, nearly always longer than style.	APHIS.

Genus HYALOPTERUS Koch.

Antennæ about as long as the body; the seventh joint about as long as the third. Sensoria small and irregularly disposed. Beak short. Eyes dark red. Wings hyaline, with slender veins. Honey-tubes short and narrow, not longer than the style.

The genus is difficult to define, as it stands too close to Aphis, but it partakes of the foregoing tribe in the long and somewhat depressed form of the body, and in a short beak. It can be considered as connecting the Callipterini with the Aphidini.

1. Hyalopterus arundinis (Fab.).

Aphis arundinis Fab.
Hyalopterus arundinis Koch.
Aphis phragmitidicola Oestl. List Aph. Minn., p. 44, 1886.

Antennæ nearly as long as the body, dusky except at base; seventh joint as long as the third, imbricated; III 0.40^{mm}, IV 0.25^{mm}, V 0.20^{mm}, VI 0.10^{mm}, VII 0.40^{mm}; third and fourth joints with numerous small sensoria, grouped irregularly on the under side. Beak short and thick, not reaching second pair of coxæ. Thorax black or blackish. Wings very hyaline, slightly iridescent; stigma long and narrow, slightly dusky. Abdomen long and narrow, tapering behind, pale green. Honey-tubes short, not longer than style, narrow, situated rather far up on the abdomen. Style about as long as the tarsi, cylindrical, slightly curved upwards.

The species is found in small colonies on the leaves of *Phragmitis communis* Linn. The individuals are all more or less covered with a whitish powder, and live closely appressed to the leaf on which they feed.

Genus MASTOPODA Oestlund, 1886.

Antennæ about as long as the body, six-jointed, the third and setaceous sixth being the longest, on no frontal tubercles. Eyes dark red. Beak moderately long. Wings as in Aphis. Legs moderately long, with the tarsi and claws atrophied. The tibiæ are truncate at tip, and furnished with a membrane, the structure of which seems to be similar to that of the Diptera, as they are able to walk with ease not only on the perpendicular,

but also on the under surface of a horizontal glass plate. The upper side of the tibial tip is furnished with a small tubercle, which probably represent the claws.

The genus is anomalous in several respects, but in general appearance and habit comes nearest to Aphis, and will therefore, I think, fall into the present tribe.

1. Mastopoda pteridis Oestl.

Mastopoda pteridis Oestl. List Minn. Aphid., p. 53, 1886.

Antennæ about as long as the body, black; III 0.55^{mm}, IV 0.20^{mm}, V 0.10^{mm}, VI 0.80^{mm}. Beak reaching second pair of coxæ. Wings with black and well defined veins; venation sometimes quite variable. Legs pale, with dusky or black tips; tibiæ quite long with a truncate and somewhat enlarged tip ending with a membranous structure, with true tarsi and claws wanting. Abdomen pale green or yellowish, with some dusky markings above. Honey-tubes rather long (0.40^{mm}), cylindrical, black. Style very short, conical and hairy as in Aphis. Length of body 1.60^{mm}, to tip of wings 2.90^{mm}.

The full grown larva, or apterous form, pale yellow, with a reddish yellow thorax, and abdomen above with tortoise-shelled dusky markings. Young larva uniformly pale yellow. Found on the under side of the fronds of *Pteris aquilina* Linn., in large colonies. They have been found only in one place although the fern is common all along the river, and appears to be a local and rare species.

Genus APHIS Linn. 1748.

Antennæ on no frontal tubercles, or on very inconspicuous ones, usually a little shorter than the body. Eyes dark red or black. Beak moderately long, never reaching abdomen except in *A. cardui.* Wings rather short and broad, deflexed in repose; venation typical. Legs moderately long, stout. Abdomen short and broad, rounded or obtuse behind. Honey-tubes of moderate length, cylindrical, or sometimes slightly incrassate, very rarely wanting. Style more or less prominent, short, thick, conical.

The most extensive genus of the family, and the species difficult to distinguish on account of their great similarity to each other. The following synoptical tables are affixed for determining the species, but which are not expected to be more than

temporary, being more or less artificial. It is still hoped that this first attempt to arrange our American species of this extensive genus in their natural order will be of some service, if not a basis for future work.

It may be convenient to recognize the following groups:

1	Forming a pseudogall by the twisting or curling of the leaves. - - - - - - -	APHIS PEMPHIGINI.
	Living unprotecte.. the food plant. - - - - -	2.
2	Last oint of the antennæ shorter than the third. -	APHIS GENUINI.
	Last joint longer than the third. - -	APHIS NECTAROPHORINI.

A. Aphis pemphigini.

SYNOPTICAL TABLE OF THE SPECIES.

1	Prothorax with a lateral tubercle. - - - - -	3.
	Prothorax with no tubercle. - - - - - - -	2.
2	Beak long, reaching third pair of coxæ; honey-tubes long. - - - - - - - - -	A. SYMPHORICARPI.
	Beak shorter; honey-tubes short. - -	A. HELIANTHI.
3	Beak long, reaching third pair of coxæ. -	A. CRATÆGIFOLIÆ.
	Beak moderately long. - - - - - - -	4.
4	Size small, dark red. - - - - -	A. CORNIFOLIÆ.
	Size larger, green or brown. - - - - - - -	5.
5	Legs white or pale. - - - - - -	A. ALBIPES.
	Legs greenish or black. - - - - -	A. CERASIFOLIÆ.

1. Aphis symphoricarpi Thomas.

Aphis symphoricarpi Thomas. Bull. Ill. St. Lab. Nat. Hist., No. 2, p. 12, 1878 (in part).

Antennæ a little shorter than the body; third and fourth joint much thickened, and sometimes almost united, with numerous irregular round or oblong sensoria; III 0.25^{mm}, IV 0.25^{mm}, V 0.22^{mm}, VI 0.12^{mm}, VII 0.35^{mm}. Beak long, 0.75^{mm}. Eyes dark brown. Wings with rather prominent blackish veins; stigma broad. Legs black, with only base of femur and tibia pale. Abdomen green, with marginal patches of black above the honey-tubes, and more or less transverse bands between the honey-tubes. Honey-tubes black, cylindrical, hardly

twice the tarsi in length (0.25^{mm}). Style very short and blunt, concolorous with abdomen. Length of body 2.30^{mm}; to tip of wings 3.50^{mm}.

Found on the leaves of *Symphoricarpus vulgaris*, at the end of branches, causing them to curl.

2. Aphis cratægifoliæ Fitch.

Aphis cratægifoliæ Fitch. Cat. Hom. N. Y. St. Cab., p. 66, 1851.

Antennæ somewhat shorter than the body, black; joints III—VI with numerous irregularly disposed sensoria, especially on the third, which becomes somewhat thickened and very uneven; III 0.40^{mm}, IV 0.25^{mm}, V 0.18^{mm}, VI 0.10^{mm}, VII 0.35^{mm}; or, in smaller specimens, somewhat less. Beak long, reaching third pair of coxæ (0.70^{mm}). Thorax all black, smooth; membrane often pale. Wings hyaline with slender brownish veins; stigma long and narrow, pointed in front, slightly dusky. Legs pale, with tips of the joints black. Abdomen greenish, or greenish-brown, with a marginal row of black patches. Honey-tubes concolorous with abdomen, about twice the length of the tarsi. Length of body 1.80–2.30^{mm}; to tip of wings 3.50–4^{mm}.

Found on the leaves of *Cratægus*, corrugating them. Specimens taken during May on *Cratægus tomentosa* Linn. were found to curl the leaves very much, and as they turned dark brown or red they became very conspicuous. What is apparently the same species was again taken during October on several species of *Cratægus*, but not causing the leaves to curl, or very slightly so. Our species should be compared with the several European ones found on the same tree.

3. Aphis cerasifoliæ Fitch.

Aphis cerasifoliæ Fitch. Ins. of N. Y., I., p. 131, 1855.

Antennæ nearly as long as the body; III 0.40^{mm}, IV 0.25^{mm}, V 0.25^{mm}, VI 0.12^{mm}, VII 0.45^{mm}; third joint with a moderate number of sensoria, round, and disposed nearly in a straight row. Beak moderately long, not reaching second pair of coxæ (0.35^{mm}). Thorax black, with membrane greenish. Wings with slender brownish veins; stigma long and pointed in front, slightly if at all dusky. Second fork much nearer the apex of the wing than to the base of the first fork. Abdomen pale green, with marginal dots or patches of darker color; a medial

and also transverse line of deeper green. Honey-tubes about twice the tarsi in length (0.25^{mm}), concolorous with abdomen, becoming dusky at apex. Length of body 2^{mm}; to tip of wings 3.50–4^{mm}.

A common species, found on the leaves of *Prunus virginiana* Linn. Their presence is usually quite conspicuous by the bunch of deformed leaves on top of the branch where they are found. The apterous form, at least, is thickly covered with whitish powder, and a great amount of liquid globules is often found among them, as is so often seen in *Schizoneura americana.*

4. Aphis albipes n. sp.

Antennæ nearly as long as the body, becoming black in winged form, but quite pale or white with only tips of the apical joints dusky in the apterous form, smooth, or nearly so; III 0.50^{mm}, IV 0.40^{mm}, V 0.30^{mm}, VI 0.15^{mm}, VII 0.45^{mm}. Beak not more than reaching second pair of coxæ (0.35^{mm}). Thorax black, membrane brownish. Legs very pale or white, with only tips of the joints, together with the tarsi, dusky. Wings hyaline, with slender veins; stigma rather long and somewhat pointed in front. Abdomen brown, with transverse bands of black; ventral reddish-brown. The larvæ are all of a reddish-brown color, with a white transverse dash on either side of the abdomen, and a larger one nearly between the honey-tubes. Honey-tubes short (0.15^{mm}), cylindrical, or slightly narrowed at base. Style nearly as long as the honey-tubes, very pale or white. Length of body 2.30^{mm}; to tip of wings 4^{mm}.

Found on the under side of the leaves of *Symphoricarpus vulgaris* Linn., together and often in company with the previous species described from the same plant.

5. Aphis helianthi Monell.

Aphis helianthi Monell. Bull. U. S. Geol. Surv. Terr., Vol. V, p. 26, 1879.

Antennæ two-thirds as long as the body, black; joints 3–5, with numerous round sensoria of various sizes; III 0.30^{mm}, IV 0.15^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.20^{mm}. Beak variable in length, in some not more than reaching the second pair of coxæ, while in others it was found to reach beyond the third pair. Head and thorax all black. Wings hyaline; stigma short and

broad. Abdomen short and broad, dark green in color, with transverse bands of black above, and a marginal row of impressed dots. Honey-tubes short, hardly longer than the tarsi (0.10^{mm}). Style about as long as the honey-tubes. Length of body 1.50^{mm}; to tip of wings 2.50–3^{mm}.

Found on the leaves and stem of *Helianthus*, corrugating the leaves.

6. Aphis cornifoliæ Fitch.

Aphis cornifoliæ Fitch. Cat. Hom. N. Y. St. Cab., p. 65, 1851.

Antennæ about as long as the body, more or less dusky; joints 3–5 with numerous small, round sensoria; III 0.30^{mm}, IV 0.20^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.25^{mm}, from which it varies more or less. Head and thorax dusky black; prothorax with a very distinct lateral tubercle. Legs pale yellow, with tips of tibia and the tarsi black. Wings hyaline, with slender slightly dusky veins. Abdomen short and broad behind, dark brown. Honey-tubes short, cylindrical, scarcely longer than the tarsi. Style short, dusky. Length of body about 1.20^{mm}; to tip of wings 2.25^{mm}.

This small species is found on the under side of the leaves of several species of *Cornus* or dog-wood, corrugating them when numerous.

B. Aphis genuini.

SYNOPSIS OF THE SPECIES.

1	Subterranean in habit.	2.
	Aerial in habit.	3.
2	Color leaden-gray or pale.	A. MIDDLETONII.
	Color pale red or pinkish.	A. TRIFOLII.
3	Honey-tubes not obvious.	A. LONICERÆ.
	Honey-tubes obvious.	4.
4	Honey-tubes slightly incrassate.	5.
	Honey tubes cylindrical.	6.
5	Stigmal vein regularly curved its whole length; second branch of the cubital arising midway between the base and the apex.	A. MARUTÆ.
	Stigmal vein only curved at base, then running straight to the apex; second branch arising near the apex.	A. MAIDIS.
6	Honey-tubes short, not longer than tarsi.	7.
	Honey-tubes longer than tarsi.	9.

7 { Style conical, acute at tip. - - - - - A. BRASSICÆ.
Style obtuse at tip. - - - - - - - - 8.

8 { Sensoria numerous, irregular; honey-tubes greenish. A. MIMULI.
Sensoria few, in a single row; honey-tubes dusky or black. A. MONARDÆ.

9 { Honey-tubes from one and a half to twice the length of the tarsi. 10.
Honey-tubes more than twice the length of the tarsi. - - 15.

10 { Joints IV and V of antennæ longer than III. - A. THASPII.
Joints IV and V less than III. - - - - - - 11.

11 { Stigma very black and conspicuous; abdomen of a deep black. - - - - - - - - - - - A. NEILLIÆ.
Stigma at most only smoky; abdomen more or less green. - 12.

12 { Joint III alone with sensoria. - - - - - - 13.
Joints 3-5 with sensoria. - - - - - A. CARDUELLA.

13 { Joint III with a single row of rather large sensoria. A. RUBICOLA.
Joint III with numerous irregularly placed sensoria. - - 14.

14 { Style long, body yellowish-green. - - - A. EUPATORII.
Style short, body greenish. - - - A. ASCLEPIADIS.

15 { Abdomen of winged form with spots or patches of white flocculent matter above. - - - - - - - - A. MACULATÆ.
Abdomen with no flocculent matter. - - - - - 16.

16 { Second branch of the cubital very near to the apex of the wing. - - - - - - - - - - - A. SALICICOLA.
Second branch from midway between the apex and the base. - 17.

17 { Color black, or at least not green. - - - - - 18.
Body with at least abdomen green. - - - - - 20.

18 { Beak reaching second pair of coxæ; sensoria all small. A. APARINES.
Beak reaching third pair of coxæ; sensoria irregular in size. - 19.

19 { Sensoria present on the fourth, in a single row; larvæ black. A. RUMICIS.
Usually no sensoria on the fourth; larvæ yellowish. A. OXYBAPHI.

20 { Honey-tubes twice the tarsi in length; sensoria on III only. A. RIPARIÆ.
Honey-tubes three times the tarsi in length; sensoria on III and IV. - - - - - - - - - - A. OENOTHERÆ.

8. Aphis middletonii Thos.

Aphis middletonii Thomas. Ins. Ill., 8th Rept., p. 99, 1879.

Apterous form: The color of a full grown specimen is leaden gray, with head more or less dusky; abdomen with marginal spots and also commonly some transverse bands of black. Eyes as usual in Aphis. Antennæ short, about one-third or not more than one-half the length of the body, dusky except at base; III

0.18^{mm}, IV 0.10^{mm}, V 0.08^{mm}, VI 0.08^{mm}, VII 0.15^{mm}. Beak rather long, reaching third pair of coxæ (0.50^{mm}). Legs more or less dusky. Honey-tubes short (0.15^{mm}), slightly thickest at base. Style short, conical, hairy. Anal plates dusky or black. Length of body 1.50–1.75^{mm}.

This peculiar species is found very plentiful on the roots of *Erigeron canadensis*, and more rarely on *Ambrosia trifida*. Dr. Thomas gives several other plants on the roots of which it is found. Winged specimens have never been taken. Young specimens are all more or less pulverulent.*

9. Aphis trifolii n. sp.

Specimens of another subterraneous species, as found on the roots of *Trifolium repens* Linn., was brought to my notice lately, but I only made some general notes at the time and have not since succeeded in finding it, and can therefore not give a full description. It can be recognized by its pale red or pinkish color, in size much smaller than the preceeding, with which it in other respects is quite similar.

10. Aphis loniceræ Monell.

Aphis lonicerœ Monell. Bull. Geol. Surv. Terr., Vol. V., p. 26, 1879.

Chaitophorus lonicera Thomas. Ins. Ill., 8th Rept., p. 104, 1879.

"*Winged individuals:* Green, often with two darker longitudinal stripes. Head and thorax brownish. Antennæ about as long as the body; frontal tubercles short, but distinct; apical joint filiform, as long as the two preceding taken together. Rostrum reaching below the second pair of coxæ. Wings hyaline; stigma rather long. Nectaries scarcely projecting above the surface of the abdomen. Lateral edges of the abdomen with four or five very short, green, mammiform tubercles. Style not perceptible. Length 2.54^{mm}; to tip of wings 4.57^{mm}." (Monell).

*Since writing the above winged specimens have been taken during the latter part of September, like the apterous also feeding on the roots near the surface of the ground. Antennæ about half the length of the body; third joint with several rather large sensoria arranged in almost a regular row. Ocelli present but small, the two lateral ones close to the compound eyes. Beak reaching second pair of coxæ. Head and throax black; abdomen dull green as in apterous, with a lateral row of dusky spots, and more or less pulverulent. Wings as usual in the genus. Honey-tubes short, about as long as the tarsi, cylindrical.

Eggs were observed scattered among the apterous form during the same time. These appear, therefore, to be laid on the roots also, and are probably further taken care of by the ants, which were always found to attend this species.

A peculiar species, found on the wild honeysuckle or *Lonicera glauca* Hill. I have seen only the wingless form, which are very pulverulent, and exude an abundant liquid secretion that, dropping on the leaves and surrounding objects, soon hardens into a white gummy substance. Antennæ nearly as long as the body, pale, slightly hairy; III 0.75^{mm}, IV 0.50^{mm}, V 0.40^{mm}, VI 0.15^{mm}, VII 0.50^{mm}. Beak reaching beyond second pair of coxæ (0.50^{mm}). Legs long, pale; tarsi rather long, with strong claws. Length of body nearly 3^{mm} in full grown specimens.

This species departs somewhat from a typical *Aphis*, but at present may as well be taken in connection with this genus.

11. Aphis maidis Fitch.

Aphis maidis Fitch. Ins. N. Y., I., p. 318, 1856.

Antennæ about two-thirds as long as the body, black; third and fourth joints with several round sensoria; III 0.30^{mm}, IV 0.15^{mm}, V 0.12^{mm}, VI 0.10^{mm}, VII 0.20^{mm}, but the length varies considerable in specimens of different size. Beak short (0.20^{mm}). Wings hyaline, with slender veins; stigma long and pointed stigmal vein curved for half of its length, then running almost straight to the apex of the wing. Second branch of the cubital near to the apex. Head and thorax black; abdomen greenish, with some black markings above. Honey-tubes short (0.12^{mm}), slightly incrassate, being widest in the middle. Style short, not more than one-half the length of the honey-tubes. Length of body 1.20^{mm}.

This species is found on all parts of the corn, often proving quite destructive when appearing in great numbers. Of late considerable attention has been given to this species, as well as others found on corn, by the state entomologist of Illinois, as found in the reports of that state. Prof. Forbes is evidently in error in considering *A. maidis* as more properly belonging to Rhopalosiphum on account of the incrassate honey-tubes. It is in all respect an Aphis.

12. Aphis marutæ Oestl.

Aphis marutæ Oestlund. Geol. Surv. Minn., 14th Rept., p. 40, 1886.

Antennæ similar to *Aphis maidis;* third joint strongly tuberculate. Beak reaching beyond second pair of coxæ (0.40^{mm}). Head and thorax shining black; prothorax with no lateral tubercle, membrane greenish. Wings with more robust veins than *A. maidis;* stigmal vein shorter, and curved its whole length; second branch of the cubital midway between the base of the first branch and the apex of the wing. Abdomen pale green, with a marginal row of black spots, and a large subquadrate patch above. Honey-tubes and style much as in the preceding species. Length of body 1.50^{mm}.

Found on *Maruta cotula* DC., or common mayweed, as growing in shaded and protected places. Similar to *Aphis maidis* in several respects, but of a much brighter green.

13. Aphis brassicæ Linn.

Aphis brassicæ Linn. Syst. Nat. II., 734.

Antennæ nearly as long as the body, dusky; third joint alone with sensoria, numerous and irregular in size; III 0.55^{mm}, IV 0.25^{mm}, V 0.25^{mm}, VI 0.10^{mm}, VII 0.40^{mm}. Beak reaching second pair of coxæ. Thorax black, with membrane of prothorax pale. Wings hyaline, with slender but distinct brownish veins. Abdomen of a dirty green or yellowish-green, pulverulent, with a marginal row of spots and transverse bands of black. Honey-tubes short and small, not longer than tarsi (0.10^{mm}); more or less dusky. Style about as long as the honey-tubes, very acute at apex. Length of body 2^{mm}.

Found not only on cultivated cabbage, to which it becomes quite destructive at times, but also often on the wild mustard, *Senapis nigra* Linn. This species is more or less pulverulent.

14. Aphis mimuli n. sp.

Antennæ a little more than one-half the body in length; joints 3–5, with numerous sensoria of varying size; III 0.25^{mm}, IV 0.15^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.20^{mm}. Beak reaching third pair of coxæ. Thorax all black. Wings thin, with slender brownish veins; stigma narrow, pointed in front; second

branch of the cubital nearer the margin than the origin of the first branch. Abdomen pale green, with no dusky markings, or only a longitudinal middle line of deeper green. Honey-tubes very short, not longer than tarsi (0.10^{mm}), concolorous with abdomen. Style about as long as the honey-tubes, conical, and obtuse at apex. Length of body 1.30^{mm}.

A small pale greenish species living on *Mimulus jamesii*, growing in damp places along the river. In size and form of the honey-tubes it comes nearest to *A. brassicæ*, but is a much smaller species, and not at all pulverulent.

15. Aphis monardæ n. sp.

Antennæ nearly as long as the body; the sensoria large, all of nearly the same size, and disposed in a single row, about six to the third joint, and two or three to the fourth; III 0.25^{mm}, IV 0.13^{mm}, V 0.12^{mm}, VI 0.08^{mm}, VII 0.20^{mm}. Beak reaching third pair of coxæ. Thorax of a deep black, prothorax with a lateral tubercle. Wings very much as in preceding species. Abdomen greenish, with much mottling of black above. Honey-tubes slightly longer than tarsi (about 0.10^{mm}), black. Style about as long as tarsi. Length of body 1.10^{mm}; to tip of wings 2.10^{mm}.

Larvæ varies from a pale green to almost black.

Found on the under side of the leaves of *Monarda fistulosa*. Distinguished from the preceding species by its smaller size, darker colors, and large sensoria of the antennæ.

16. Aphis thaspii n. sp.

Antennæ about two-thirds as long as the body; third joint with numerous sensoria, the fourth at most with only a few; joints 4–7 imbricated; III 0.40^{mm}, IV 0.17^{m}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.28^{mm}. Beak reaching second pair of coxæ, or slightly beyond (0.35^{mm}). Head and thorax all bl[illegible] membrane sometimes paler. Abdomen of a dusky gr[illegible] times almost black. Wings with slender veins; sti[illegible] and pointed in front, slightly dusky. Honey-tube[illegible] the tarsi in length (0.20). Style about as long [illegible] obtuse. Length of body $1.50–2^{mm}$; to tip of [illegible]

Found on the umbels of *Thaspi*[illegible] accompanied by ants.

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with a lateral tubercle. Wings with very slender veins; costal yellowish; stigma slightly dusky, about as long again as broad. Abdomen of a dull green, with a marginal row of black spots. Honey-tubes about half as long again as the tarsi (0.15^{mm}). Style slightly shorter. Length of body 1.25^{mm}; to tip of wings 3^{mm}.

Found rather common on several species of *Circium*, or thistle.

20. Aphis asclepiadis Fitch.

Aphis asclepiadis Fitch. Cat. Hom. N. Y. St. Cab., p 65, 1851.
Siphonophora asclepiadis Thomas. Bull. Ill. St. Lab. Nat. Hist., No. 2, p. 7, 1878.

Antennæ two-thirds as long as the body, third joint with numerous irregularly placed sensoria; III 0.35^{mm}, IV 0.18^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.25^{mm}. Beak nearly reaching third pair of coxæ. Head and thorax shining black; prothorax with a lateral tubercle, membrane greenish. Wings hyaline, with very slender veins; stigma elongate, grayish. Abdomen pale green, with a marginal row of impressed black dots, also some black above on the last segments. Honey-tubes about twice the tarsi (0.20^{mm}). Style not more than one-half the honey-tubes. Length of body 1.50^{mm}; to tip of wings 3–3.10^{mm}.

A rather common species, especially on *Asclepias cornuti*, but also found on *Euphorbia* and *Apocyne*. What I quote as *Aphis apocyni* in my list of the Aphididæ of Minnesota, on the authority of Dr. Thomas, I consider now to be the same as *Aphis asclepiadis*.

21. Aphis rubicola n. sp.

Antennæ nearly as long as the body; joint 3 with only a few (3–6) very large sensoria in a single row; III 0.18^{mm}, IV 0.12^{mm}, V 0.10^{mm}, VI 0.08^{mm}, VII 0.22^{mm}. Head and thorax shining black; membrane of prothorax greenish. Wings with slender, brownish veins; stigma elongate. Abdomen greenish. Honey-tubes concolorous with abdomen, twice the tarsi in length (0.15^{mm}). Style half as long as the honey-tubes, pale, hairy. Length of body 0.75–1^{mm}; to tip of wings 2^{mm}.

This is one of our smallest Aphis, found on the under side of the leaves of *Rubus strigosus* Mx. Should be easily recognized from our other species on account of its small size and simple sensoria.

22. Aphis maculatæ n. sp.

Antennæ about two-thirds as long as the body, slightly pubescent with spreading hairs; third joint with numerous distinct sensoria; III 0.40^{mm}, IV 0.20^{mm}, V 0.20^{mm}, VI 0.12^{mm}, VII 0.35^{mm}. Beak nearly reaching third pair of coxæ (0.50^{mm}). Thorax of a deep black; prothorax with a large and distinct lateral tubercle. Wings hyaline, with slender, brownish veins; stigma elongate, smoky; second branch of the cubital nearer to the margin than the origin of the first branch. Abdomen blackish, with tubercle to the segments along each side; dorsum with patches of a pure white flocculent matter, disposed somewhat in rows, ventral uniformly pulverulent. Honey-tubes about three times the tarsi in length (0.30^{mm}), dusky. Style about as long as the tarsi, hairy. Length of body 2^{mm}; to tip of wings 4^{mm}.

A species found early in the season on dog-wood (*Cornus*), on the under side of the leaves. Very characteristic on account of the white flocculent patches of the abdomen, found both in the winged and wingless form. The antennæ in the long and spreading hairs comes nearer to the hirsute character of Chaitophorus than any other Aphis with which I am acquainted.

23. Aphis rumicis Linn.

Aphis rumicis Linn. Syst. Nat., II., 734.

Antennæ two-thirds as long as the body; third joint with numerous irregular sensoria, fourth commonly with a few rather large ones in a single row; III 0.40^{mm}, IV 0.30^{mm}, V 0.25^{mm}, VI 0.12^{mm}, VII 0.35^{mm}; last joint varies considerable, sometimes even as long as the third. Beak about 0.50^{mm} long. Thorax all black, shining; prothorax with a lateral tubercle. Legs mostly with pale or whitish tibiæ. Wings pellucid, with very slender veins; stigma elongate, grayish. Abdomen black or blackish. Honey-tubes black, somewhat more than twice the tarsi in length (0.25^{mm}). Style half as long as the honey-tubes.

One of our most common species, found on a great number of different plants, but more often on *Chenopodium* and *Rumex*. The synonyms of this species are very numerous, some authors giving as many as twenty, but from the scanty descriptions of the older entomologists, especially in Aphis, it becomes very difficult to say which are synonyms and which are not. The whole subject needs a careful revision.

24. Aphis oxybaphi n. sp.

Antennæ a little shorter than the body, black; joint three with numerous small round sensoria; transition from the sixth to the seventh abrupt; III 0.30^{mm}, IV 0.25^{mm}, V 0.23^{mm}, VI 0.15^{mm}, VII 0.25^{mm}. Beak about 0.50^{mm} long. Prothorax with a lateral tubercle. Wings hyaline; stigma long and narrow, pointed in front; second branch of cubital nearer the apex than the base of the first branch. Wings yellowish at base. Legs with black femora except first pair; all the tibiæ pale, but with black tarsi. Abdomen of a uniform pale reddish-brown, with a marginal row of black patches. Honey-tubes hardly longer than the tarsi in the winged male, but much longer in the female and in the wingless form; cylindrical, black. Style short and stout, conical. Length of body 1.50–1.80^{mm}. The larvæ are much paler, almost of a lemon-yellow, with some mottlings of darker color on the dorsum of the abdomen.

Found on the stems and leaves of *Oxybaphus angustifolius.*

25. Aphis aparines Fab.

Antennæ about as long as the body, on moderately developed frontal tubercles, which are slightly gibbous on the inner side; sensoria small and irregularly placed on joints 3–5; III 0.30^{mm}, IV 0.25^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.30^{mm}. Beak reaching second coxæ (0.35^{mm}). Prothorax with no lateral tubercle, shining black. Stigma elongate, slightly dusky. Abdomen black. Honey-tubes about twice the length of the tarsi (0.25^{mm}), cylindrical, black. Length of body 1.40^{mm}; to tip of wings 2.80^{mm}.

Found on *Galium aparine* Linn.

26. Aphis œnotheræ n. sp.

Antennæ shorter than the body, black, or only base of third joint pale; joints 3–5 with a moderate number of rather small sensoria; III 0.25^{mm}, IV 0.18^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.25^{mm}. Beak moderately long. Thorax of a deep dull black; prothorax with a tubercle, membrane greenish. Abdomen bright green, with a marginal row of black spots. Honey-tubes about three times the tarsi (0.30^{mm}). Style about half as long as the honey-tubes, cylindrical, very acute at tip, dusky or black. Length of body 1.50^{mm}; to tip of wings 3^{mm}. Larvæ pale green.

Found among thc seed-pods and upper stems of *Œnothera*. This as well as the foregoing species shows some affinities to the next tribe.

27. Aphis ripariæ Oestl.

Aphis ripariæ Oestl. Geol. Surv. of Minn., 14th Rept., p. 41, 1886.

Antennæ about as long as the body, black, except base of third joint; third joint with numerous small sensoria, seventh nearly as long as the third. Beak reaching second coxæ. Thorax dull black; prothorax with a lateral tubercle. Second branch of the cubital nearer to the apex of the wing than the base of the first branch. Honey-tubes about twice the length of the tarsi. Style about as long as the tarsi, cylindrical, obtuse at apex. Length of body 2^{mm}.

Found on the under side of the leaves of *Vitis riparia* Mx.

28. Aphis salicicola (Thos.).

Siphonophora salicicola Thos. Bull. Ill. St. Lab. Nat. Hist., 2, p. 8, 1878.

Aphis salicicola Monell. Bull. U. S. Geol. Surv. Terr., Vol. V, No. 1, p. 24, 1879.

Antennæ shorter than the body; third joint with a single row of rather small sensoria; III 0.30^{mm}, IV 0.15^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.25^{mm}. Beak reaching third coxæ. Thorax all black; prothorax with a lateral tubercle. Wings hyaline, with slender, brownish veins; second branch of cubital vein very near to the apex of the wing. Abdomen dark green, with more or less black above. Honey-tubes about three times the tarsi in length, or somewhat more, pale green, becoming dusky at tip, cylindrical, but slightly widest at base. Style long and Nectarophora-like, about one-third the honey-tubes in length, slightly curved and thickest in the middle. Length of body 1.50^{mm}; to tip of wings 3.30^{mm}.

Found on the under side of the leaves of *Salix discolor*. This species also shows strong affinities to Nectarophora, but is undoubtedly best taken in connection with Aphis, as has been done by Mr. Monell.

C. Aphis nectarophorini.

SYNOPSIS OF THE SPECIES.

1	Seventh joint less than twice the third in length. - - -	2.
	Seventh at least twice as long as the third. - - -	9.
2	Honey-tubes short, about twice the tarsi in length. - - -	3.
	Honey-tubes longer. - - - - - - -	4.
3	Antennæ not as long as the body. - - - -	A. MALI.
	Antennæ as long as body. - - -	A. PRUNIFOLLÆ.
4	Honey-tubes knobbed at apex. - - -	A. FRIGIDÆ.
	Honey-tubes not knobbed. - - - - -	5.
5	Beak reaching abdomen. - - - - -	A. CARDUI.
	Beak not reaching abdomen. - - - - -	6.
6	Beak very short, not reaching second coxæ. - -	A. ADIANTI.
	Beak longer. - - - - - - - -	7.
7	Prothorax with no lateral tubercle. - - -	A. ANNUÆ.
	Prothorax with a tubercle. - - - - -	8.
8	Second branch of cubital near apex of wing. -	A. FRONDOSÆ.
	Second branch midway. - - - -	A. POLANISIÆ.
9	Antennæ longer than body. - - -	A. SETARIÆ.
	Antennæ shorter. - - - - - - -	10.
10	Abdomen of uniform color, pale brown. - - -	A. SPIRÆÆ.
	Abdomen yellowish, with a dorsal patch of black.	A. AGERATOIDES.

29. Aphis mali Fab.

Antennæ shorter than the body, black; III 0.28^{mm}, IV 0.15^{mm}, V 0.15^{mm}, VI 0.08^{mm}, VII 0.40^{mm}. Head and thorax black, with membrane of prothorax usually green. Wings rather long, hyaline; second branch of the cubital rather near to the apex. Legs pale, with black joints and tarsi. Abdomen green, with a row of black dots on each side. Honey-tubes about twice the tarsi in length, more or less dusky.

Found rather plentiful throughout the season on the common apple, the crab-apple, as well as the mountain ash. They are found mostly on the leaves, but when very numerous also on the tender twigs. Dr. Fitch's *Aphis malifoliæ* appears to be but a variety.

30. Aphis prunifoliæ Fitch.

Aphis prunifoliæ Fitch. Ins. N. Y., I, p. 122. Trans. N. Y. St. Ag. Soc., Vol. XIV, p. 826, 1855.

Antennæ as long as the body. Head and thorax shining black; abdomen pale green, with a marginal row of dots. Honey-tubes cylindrical, reaching to the tip of the abdomen.

A species very similar to the foregoing found on the plum tree. Our species appears to be distinct from the European *A. pruni*, but should be further compared. I have observed the species but once in Minnesota, and at the time only took some general notes. Thomas and Saunders consider it identical with the European, while Monell and Osborn give it as above.

31. Aphis frigidæ Oestl.

Aphis frigidæ Oestl. Geol. Surv. Minn., 14th Rept., p. 46, 1886.

Antennæ a little shorter than the body; III 0.25^{mm}, IV 0.15^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.35^{mm}. Beak reaching third coxæ. Thorax black. Wings hyaline, with black and rather prominent veins; second branch of cubital nearer the apex than base of the first branch. Abdomen longer than broad, rather acute behind. Honey-tubes long and slender, cylindrical, being enlarged and round at tip, as if ending with a knob, about 0.40^{mm}. Style short and conical, concolorous with abdomen. Length of body 1.30^{mm}.

A very peculiar species, found occasionally together with Nectarophora frigidæ on *Artemisia frigida.* It is a small active species, of grayish color from the pulverulent body, found mostly on top of the branches above a colony of the above named Nectarophora.

32. Aphis cardui Linn.

Antennæ black, nearly as long as the body; third joint with numerous sensoria; III 0.45^{mm}, IV 0.30^{mm}, V 0.20^{mm}, VI 0.10^{mm}, VII 0.55^{mm}. Beak very long, reaching beyond third coxæ. Thorax shining black; membrane of prothorax yellowish. Wings hyaline, slightly iridescent; stigma rather broad. Legs pale brown, with tips of joints black. Abdomen brownish or greenish-brown, with a marginal row of black spots, usually with a large quadrate patch of black above; ventral pale greenish-

brown. Honey-tubes cylindrical, somewhat enlarged at base, about 0.30^{mm} long, black. Style short, conical, concolorous with abdomen. Length of body 2^{mm}; to tip of wings 3.50^{mm}.

Found on *Circium lanceolatum.* Has the beak longer than any other Aphis with which I am acquainted. The color varies a great deal, especially of the larvæ, from a decided yellow to a brownish-green. Numerous ants were found to attend this species.

33. Aphis adianti (Oestl.).

Siphonophora adianti Oestl. Geol. Surv. Minn., 14th Rept., p. 26, 1886.

Antennæ about as long or longer than the body, black except at base, on small frontal tubercles; III 0.30^{mm}, IV 0.20^{mm}, V 0.20^{mm}, VI 0.10^{mm}, VII 0.45^{mm}. Beak short, not reaching second coxæ. Abdomen short and broad, rounded behind. Honey-tubes long (0.35^{mm}), cylindrical, dusky above. Style short, conical, concolorous with abdomen. Legs rather short, pale in color. Whole body of a lemon-yellow, with the antennæ, tips of the legs, and honey-tubes, dusky or black.

Found on the fronds of *Adiantum pedatum* Linn. Although this species has been observed from June until October, and is by no means a rare form, none but wingless have yet been found. It is undoubtedly an Aphis, and not Siphonophora, as I at first considered it.

34. Aphis annuæ Oestl.

Aphis annuæ Oestl. Geol. Surv. Minn., 14th Rept., p. 43, 1886.

Antennæ a little shorter than the body, black; III 0.30^{mm}, IV 0.25^{mm}, V 0.20^{mm}, VI 0.10^{mm}, VII 0.50^{mm}. Head and thorax shining black; prothorax with no lateral tubercle. Wings long; second branch of the cubital very short and near the margin of the wing. Abdomen dull green, sometimes with a marginal row of black spots. Honey-tubes about twice the tarsi in length, black. Style about half as long as the honey-tubes, black. Length of body 2^{mm}; to tip of wings 3.50^{mm}.

Found on leaves and stem of *Poa annua* Linn.

35. Aphis frondosæ Oestl.

Aphis frondosæ Oestl. Geol. Surv. Minn., 14th Rept., p. 38, 1886.

Antennæ about as long as the body, black; joints 3–5 with sensoria placed in a single row; III 0.35^{mm}, IV 0.25^{mm}, V 0.25^{mm}, VI 0.15^{mm}, VII 0.45^{mm}. Thorax all black. Wings hyaline, with narrow, blackish veins. Second branch of cubital nearer the margin of the wing than to the base of the first branch. Abdomen greenish, with more or less marking of black above. Honey-tubes about 0.30^{mm} long, black. Style conspicuous, about half the honey-tubes in length, slightly curved as in Nectarophora. Length of body about 1.80^{mm}.

Found in large colonies on *Bidens frondosa* Linn.

36. Aphis polanisiæ Oestl.

Aphis polanisiæ Oestl. Geol. Surv. Minn., 14th Rept., p. 42, 1886.

Antennæ about as long as the body, or often somewhat shorter, on inconspicuous frontal tubercles; third and fourth joints with numerous sensoria. III 0.30^{mm}, IV 0.15^{mm}, V 0.12^{mm}, VI 0.10^{mm}, VII 0.20^{mm}. Head and thorax black; prothorax with membrane green, also with a lateral tubercle. Abdomen greenish, or yellowish-green, with a marginal row of dots, and a large quadrate patch of black above. Honey-tubes about twice the tarsi in length, concolorous with abdomen or slightly dusky. Style rather thick and conical, concolorous with abdomen. Length of body 1.80–2^{mm}; to tip of wings 3.60^{mm}.

Found on the seed-pods and leaves of *Polanisia graveolens* Raf. The wingless form are usually of a uniform green with the pods on which they are found.

37. Aphis setariæ (Thos.).

Siphonophora setariæ Thos. Bull. Ill. St. Lab. Nat. Hist., 2, p. 5, 1878.

Aphis setariæ Monell. Bull. U. S. Geol. Surv. Terr., Vol. V, 2, p. 23, 1879.

Antennæ about as long as the body, or often longer, on inconspicuous frontal tubercles; third joint with sensoria, and tuberculate. III 0.30^{mm}, IV 0.20^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.60^{mm}. Thorax dull black, prothorax with a lateral tubercle. Legs very pale, with dusky joints and tarsi. Wings hyaline;

econd branch rather near the apex; stigma slightly dusky. Abdomen pale brown. Honey-tubes dusky, about 0.25^{mm}. Style very pale, almost white, fully one-half the honey-tubes in length.

Found on *Setaria glauca* Beauv., *Panicum crus-galli* Linn, and on *Ampelopsis quinquefolia* Mx.

38. Aphis spiraeæ n. sp.

Antennæ on slight frontal tubercles, nearly as long as the body, black; third joint thickest and tuberculate, the distinction between third and fourth often subobsolete; III 0.30^{mm}, IV 0.20^{mm}, V 0.20^{mm}, VI 0.10^{mm}, VII 0.55^{mm}. Beak stout, reaching second coxæ. Head and thorax black; prothorax with a tubercle. Wings with narrow veins; stigma black, pointed in front, elongate. Legs very pale, but with black joints and tarsi. Abdomen of a uniform dark reddish-brown. Honey-tubes long and slender, black. Style as long as the tarsi, straight, pale or almost white. Length of body 2^{mm}; to tip of wings 3.50^{mm}.

Found on *Spiræa salicifolia* Linn.

39. Aphis ageratoidis Oestl.

Aphis ageratoidis Oestl.

Antennæ on inconspicuous frontal tubercles, somewhat shorter than the body, black; III 0.25^{mm}, IV 0.18^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.50^{mm}; third and fourth joints with sensoria. Beak reaching second coxæ. Thorax black; prothorax with a tubercle; membrane greenish. Abdomen pale yellow, with a dorsal patch of dark green, which is much longer than broad. Honey-tubes twice the tarsi in length, black. Style slender, pale yellow, about as long as the tarsi. Length of body 1.60^{mm}; to tip of wings 3^{mm}.

Found on the flower heads of *Eupatorium ageratoides* Linn.

The following Aphidinæ have been recorded as American, but not yet found here:

Sipha rubifolii Thomas,* found on the under side of leaves of the common blackberry.

Aphis cerasicolens Fitch, on the common black cherry tree (*Cerasus serotina*).

Aphis sambucifoliæ Fitch, on the under side of the leaves of elder.

Aphis circæzandis Fitch, on *Galium circæzans*.

Aphis gossypii Glover, on the cotton plant.

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* The genus Sipha is similar to Aphis, but the antenna is only six-jointed, and similar to that of Mastopoda.

Aphis vitis Scop., on tame grape vines.
Aphis quercifoliæ Walsh, on the oak.
Aphis coriopsidis (Thomas), on the heads and flower stalks of *Coriopsis aristosa.*
Aphis diospyri Thomas, on the leaves of *Diospyros virginiana.*
Aphis vernoniæ Thomas, on the under side of the leaves of *Vernonia fasciculata.*
Aphis cephalanthi Thomas, on young twigs and the leaves of the button-bush (*Cephalanthus*).
Aphis impatientis Thomas, found on *Impatiens fulva.*
Aphis lutescens Monell, on *Asclepias syriaca.*
Aphis calendulicola Monell, on the under side of the leaves of *Calendula micrantha.*
Aphis medicaginis Koch, found on *Caragana arborescens, Robinia viscosa* and *Melilotus italica*, according to Monell.
Aphis atriplicis Linn., a common aphis on the Chenopodiaceæ, according to the same author.
Aphis hyperici Monell, on the young twigs and under side of the leaves of *Hypericum kalmianum*, and *H. prolificum* according to Thomas.
Aphis nerii Kalt., on oleander.
Aphis cucumeris Forbes, on *Cucumis* and allied plants.
Aphis citri Ashmead, on *Citrus.*

Genus SIPHOCORYNE Passerini, 1860.

Antennæ on no frontal tubercles, shorter than the body; third joint very tuberculate, so as to appear as serrate on the under side; seventh joint not longer than the third. Beak moderately long. Wings and legs as in Aphis. Honey-tubes moderately long, rarely long, distinctly clavate. Style short.

The genus is difficult to define, as we have no very distinct characters to rely upon. It is often defined as similar to Rhopalosiphum except in wanting the frontal tubercles, but as this is not a reliable character in all cases, Mr. Monell has suggested that this genus be united with Rhopalosiphum, which then, taken in its widest sense, would be known especially by the clavate honey-tubes. Although we may not put that importance on the presence or absence of frontal tubercles, as it has been customary to do, I still think it is a good generic character, and helps us to readily separate the Aphidini from the Nectarophorini. I would therefore retain the present genus for those species with clavate honey-tubes and the antennæ on no frontal tubercles. Besides, the antennæ are shorter than the body, and with a much tuberculate third and also sometimes fourth joint, so as to appear as serrate and slightly curved. The genus is also more especially confined to the Umbelliferæ.

The species within our district are not very numerous, and may be separated as follows:

1	Joint III as long as IV+V. - - - - -	S. XANTHII.
	Joint III as long as IV+V+VI. - . - - - -	2.
2	Abdomen with a large dorsal patch of black. -	S. ARCHANGELICÆ.
	Abdomen only with irregular markings of darker green.	S. SALICIS.

1. Siphocoryne archangelicæ Oestl.

Siphocoryne archangelicæ Oestl. Geol. Surv. Minn., 14th Rept., p. 36, 1886.

Antennæ not more than one-half the length of the body, black; third and fourth joint very much tuberculate and serrate, and almost connate; III 0.40^{mm}, IV 0.15^{mm}, V 0.10^{mm}, VI 0.10^{mm}, VII 0.15^{mm}. Beak short, not more than reaching second coxæ. Head and thorax shining black; prothorax with no lateral tubercle, membrane green. Stigma long and narrow; stigmal vein curved its whole length and terminating midway between the stigma and second branch of the cubital. Abdomen greenish, with a patch of black above. Honey-tubes concolorous with abdomen or slightly dusky, reaching to the tip of the style, widening to twice the diameter in the middle. Style short, conical. Length of body $2\text{–}2.50^{mm}$; to tip of wings 3.50^{mm}.

Found on the umbels of *Archangelica atropurpurea* Hoffm.

2. Siphocoryne salicis (Monell).

Rhopalosiphum salicis Monell. Bull. U. S. Geol. Surv. Terr., Vol. V, No. I, p. 26, 1879.

Antennæ about half as long as the body; third and fourth joints subconnate, very rough and serrate; III 0.45^{mm}, IV 0.15^{mm}, V 0.15^{mm}, VI 0.10^{mm}, VII 0.30^{mm}. Beak reaching beyond second coxæ and much longer than in preceding species. Origin of the second branch of cubital nearer to the margin of the wing than to the first branch. Stigmal vein running straight to the margin for half its length, and terminating nearer to the second branch than to the stigma. Abdomen green, with some transverse markings of deeper color above. Honey-tubes reaching tip of abdomen (0.35^{mm}), enlarged to twice their diameter in the middle. Style about one-third as long as the honey-tubes, robust. Length of body 2^{mm}; to tip of wings 3.50^{mm}.

Found on the leaves of *Salix lucida*. Specimens here are somewhat larger than that given by Mr. Monell.

3. Siphocoryne xanthii Oestl.

Siphocoryne xanthii Oestl. Geol. Surv. Minn., 14th Rept., p. 36, 1886.

Antennæ about one-half the length of the body; third and fourth strongly tuberculate; III 0.35^{mm}, IV 0.20^{mm}, V 0.15^{mm}, VI 0.08^{mm}, VII 0.30^{mm}. Beak not reaching second coxæ. Thorax black. Second branch about midway between the margin of the wing and origin of first branch. Abdomen yellowish-green, with transverse markings of deeper green. Honey-tubes pale, reaching to or beyond tip of abdomen, enlarging in the middle or slightly above to twice the diameter at base. Style as long as the tarsi, curved. Length of body 2^{mm}.

Found on the under side of the leaves of *Xanthium canadense* Mill.

In my preliminary list of the Aphididæ of Minnesota I give *S. xanthii* as a typical American species of the genus in question, which should have been *S. archangelicæ*, as *xanthii* is not typical but partakes somewhat of the next tribe, coming near to Myzus.

TRIBE NECTAROPHORINI.

Antennæ generally longer than the body, on distinct frontal tubercles; the setaceous seventh joint often longer than the third. Beak long. Legs long and slender. Abdomen nearly always longer than broad, cylindrical, widest in middle and pointed behind. Honey-tubes long, cylindrical, or enlarged in the middle and clavate. Style long, nearly always acute and somewhat curved upward.

As before stated, the tribes of this sub-family are difficult to define, as there are exceptions to every character with which we are acquainted, yet the division appears to be natural. The present tribe, as a rule, is known by a larger size, abdomen long and more or less pointed behind. All the appendages are also longer in proportion to the body than in the two preceding tribes, showing a greater activity and varied mode of life. The great majority are found on annual plants, and more rarely on the leaves of shrubs or trees.

The genera are not as well defined in this tribe as what is generally the case in the family, and authors, therefore, differ much in regard to their number and extent. We would recognize the following genera as American:

1	Honey-tubes cylindrical. - - - - - - - -	2.
	Honey-tubes incrassate. - - - - - - - -	3.
2	Antennæ on prominent and approximate frontal tubercles. - - - - - - - - - -	NECTAROPHORA.
	Frontal tubercles not approximate; gibbous, as is also the first joint. - - - - - - - - - -	MYZUS.
3	Prothorax with a lateral tubercle; wings clouded.	MACROSIPHUM.
	Prothorax with no lateral tubercle. - -	RHOPALOSIPHUM.

Genus MYZUS Passerini, 1860.

Antennæ about as long as the body, situated on moderately distinct frontal tubercles, which are gibbous on the inner side. First joint of the antenna also gibbous. Legs moderately long. Honey-tubes rather long, cylindrical. Style moderately long. Body often with capitate hairs.

It may still be considered as an open question if we are justified or not in retaining the present genus. This, as well as the following genus, partakes more or less of the three tribes of the Aphidinæ, and may be considered as intermediate forms, which it becomes convenient thus to put together in a separate genus.

Some of the species partake strongly of the Callipterini in their pale colors and capitate hairs of the body; the length of the antenna is mostly that of the Aphidini, and also often in the shape and size of the body; but most of the characters ally them with the tribe under consideration.

The following species have been found in Minnesota:

1	Corrugating the leaves. - - - - -	M. RIBIS.
	Not corrugating the leaves. - - - - - - -	2.
2	Wingless form with capitate hairs. - - -	M. ROSARUM.
	With no capitate hairs. - - - - - - -	3.
3	Color of body black. - - - - - -	M. CERASI.
	Color of body green. - - - - - -	M. ACHYRANTES.

1. **Myzus cerasi** (Fab.).

Aphis cerasi Fab.
Myzus cerasi Pass.

Antennæ about three-fourths the length of the body, black; III 0.40mm, IV 0.25mm, V 0.20mm, VI 0.10mm, VII 0.30mm. Honey-tubes about 0.35mm long, black; style about one-third as long. The winged form is shining black, but the wingless forms are usually of a dull black or brown. Abdomen short and very broad, giving an ovoid or globose outline to the body. The males have the antennæ much longer than the body, according to Buckton.

This species is very common on the cultivated cherry, and at times appears in enormous numbers. They are mostly found on the leaves, but when very numerous will also attack other parts of the tree. This species comes nearest to Aphis in general appearance and habit, and departs more from the typical Myzus than any other species of the genus.

2. **Myzus rosarum** (Walk.).

Aphis rosarum Walk.
Siphonophora rosarum Koch.
Myzus potentillæ Oestl. Geol. Surv. Minn., 14th Rept., p. 30, 1886.

Antennæ as long or a little longer than the body, black; III 0.55mm, IV 0.30mm, V 0.30mm, VI 0.12mm, VI 0.45mm. Beak reaching to or slightly beyond second coxæ. Legs black, with base of the femora and tibiæ paler. Abdomen greenish, with more or less black above in the form of transverse bands. Honey-tubes pale, about three times the tarsi. Style short, acute, pale. Length of body 2mm.

The larvæ of this species are provided with capitate hairs.

Found on the wild rose and on *Potentilla anserina* Linn.

Last year I described this species as new from the Potentilla, but I have since found the same on the rose, and this led me to compare it with Buckton's *Siphonophora rosarum*, with which it appears to be identical.

3. Myzus ribis (Linn.).

Aphis ribis Linn.
Myzus ribis Pass.

Antennæ longer than the body, black; third and fourth joints strongly tuberculate, and with numerous sensoria; III 0.60^{mm}, IV 0.40^{mm}, V 0.40^{mm}, VI 0.10^{mm}, VII $0.90–1.10^{mm}$. Beak rather long, about 0.50^{mm}. Head and thorax shining black; abdomen pale green or yellowish-green, with a large quadrate patch of black above, the margin with a row of black dots. Honey-tubes pale or but slightly dusky, cylindrical, or sometimes widening in the middle, and thus approaching to the following genus; about 0.40^{mm} long. Style conical, concolorous with abdomen, about one-third as long as the honey-tubes. Length of body 2^{mm}; to tip of wings 3.75^{mm}. Larvæ very pale, and with capitate hairs.

Found on the cultivated currant, corrugating the leaves. *Rhopalosiphum ribis* Koch, I think, is but a variety of the above.

4. Myzus achyrantes (Monell).

Siphonophora achyrantes Monell. Bull. U. S. Geol. Surv. Terr., Vol. V, No. 1, p. 18, 1879.
Myzus malvæ Oestl. Geol. Surv. Minn., 14th Rept., p. 31, 1886.

Antennæ about as long as the body, black; III 0.55^{mm}, IV 0.45^{mm}, V 0.35^{mm}, VI 0.15^{mm}, VII 0.50^{mm}. Beak reaching second coxæ. Abdomen pale green, with transverse markings above of black, often becoming confluent into a patch above the honey-tubes. Honey-tubes cylindrical or more rarely slightly enlarged in the middle as in preceding species, pale, becoming dusky at the apex. Style long, slender, slightly curved upward. Length of body 2.50^{mm}; to tip of wings 4^{mm}.

This species shows much in common with Nectarophora, in which genus it was also placed by Mr. Monell, who first described the same.

Genus RHOPALOSIPHUM Koch, 1854.

Antennæ on more or less distinct frontal tubercles, about as long as the body or sometimes much longer. Beak of variable length. Prothorax with no lateral tubercle. Honey-tubes enlarged in the middle or clavate, moderately long, or sometimes very long. Style also varies from small and slender to the large curved one of the next genus.

The characters of this genus vary to a great extent, and the only character that is anything like constant is the clavate honey-tubes. The smaller species, with antennæ about as long as the body, partake a good deal of the Aphidini; while the larger species with long antennæ and distinct frontal tubercles are more closely related to the following genera. The following species have been found within our district:

1	Style small and slender; of moderate size.	2.
	Style long and more robust; size larger.	3.
2	Antennæ shorter than body; veins robust.	R. SEROTINÆ.
	Antennæ a little longer than the body; veins normal.	R. RHOIS.
3	Style conical.	R. SOLANI.
	Style large and curved upward.	4.
4	Antennæ excessively long; size large.	R. ONOCLEÆ.
	Antennæ a little longer than body; size not so large.	5.
5	Abdomen with a dorsal patch of black.	R. DIANTHI.
	Abdomen with no dorsal patch.	R. NABALI.

1. Rhopalosiphum rhois Monell.

Rhopalosiphum rhois Monell. Bull. U. S. Geol. Survey Terr., Vol. V, No. 1, p. 27, 1879.

Antennæ a little longer than the body, black, on rather inconspicuous frontal tubercles; III 0.50^{mm}, IV 0.40^{mm}, V 0.30^{mm}, VI 0.15^{mm}, VII 0.50^{mm}. Beak reaching second coxæ. Head and lobes of thorax all black, membrane somewhat paler. Wings with slender, black veins. Abdomen brownish-yellow, but often greenish. Honey-tubes about 0.40^{mm} long, clavate. Style small and slender, about one-third the honey-tubes in length. Length of body $1.60–2^{mm}$.

This species is found on the under side of the leaves of *Rhus glabra*, mostly along the midvein. The apterous forms are reddish-brown, but the winged form often shows more or less of the greenish color, especially on the abdomen.

2. Rhopalosiphum serotinæ n. sp.

Antennæ shorter than the body; the sensoria not very numerous, but large and distinct; III 0.35^{mm}, IV 0.30^{mm}, V 0.22^{mm}, VI 0.12^{mm}, VII 0.35^{mm}. Beak reaching second coxæ. Head and thorax brownish, abdomen green. Wings with very prominent and robust veins, especially the first and second discoidal; stigma very narrow, long. Honey-tubes mostly concolorous with abdomen, becoming somewhat dusky, widest in the middle, contracting near the apex which is rounded or knob-like. Style short, concolorous with abdomen. Length of body about 1.80^{mm}.

A strongly characterized species found on *Solidago serotina*. It is intermediate between Siphocoryne and the present genus.

3. Rhopalosiphum solani (Thos.).

Megoura solani Thomas. Ins. Ill., 8th Rept., p. 73, 1879.

Antennæ a little longer than the body, on rather prominent frontal tubercles. Honey-tubes long, extending beyond the tip of the abdomen, much dilated in the middle. Style about one-third as long as the honey-tubes, rather thick, conical. Head and thorax black; abdomen greenish.

Found mostly solitary on cultivated tomato.

4. Rhopalosiphum dianthi (Schrank).

Rhopalosiphum sonchi Oestlund. Geol. Surv. Minn., 14th Rept., p. 34, 1886.

Antennæ about as long as the body, black; joints 3–5 with numerous rather small, round sensoria; III 0.70^{mm}, IV 0.45^{mm}, V 0.35^{mm}, VI 0.12^{mm}, VII 0.75^{mm}. Beak reaching second coxæ. Thorax black, with membrane greenish. Abdomen green, with a marginal row of black spots, and a large dorsal patch of the same color. Honey-tubes about 0.50^{mm} long, pale brown. Style about half as long as the honey-tubes, curved upward. Length of body about 2^{mm}.

In my last report I described this species as found on *Sonchus asper*, but which on further study appears to be the same as the *dianthi* of Europe.

5. Rhopalosiphum nabali Oestl.

Rhopalosiphum nabali Oestlund. Geol. Surv. Minn., 14th Rept., p. 34, 1886.

Antennæ longer than the body; joints 3–5 with numerous small sensoria that give a tubercular or rough surface to these joints; III 1.10^{mm}, IV 0.65^{mm}, V 0.55^{mm}, VI 0.10^{mm}, VII I.20^{mm}. Beak reaching slightly beyond second coxæ. Thorax dusky brown, shining. Abdomen greenish, with some dorsal bands of dusky markings. Honey-tubes long (about 0.75^{mm}), and much dilated in the middle. Style large and very conspicuous, about half as long as the honey-tubes, widest in the middle and curved upward. Length of body 2.50–3^{mm}.

Found very numerous on the upper stalk and flower heads of *Nabalus albus*.

6. Rhopalosiphum ampullata (Buckt.).

Amphorophora ampullata Buckton. Monograph of British Aph., Vol. I, p. 187, 1876.

Apterous form: Antennæ about twice as long as the body, on very conspicuous frontal tubercles; III 1.30^{mm}, IV 1.20^{mm}, V 1^{mm}, VI 0.30^{mm}, VII 1.65^{mm}. Eyes bright red. Honey-tubes long, (about 0.80^{mm}) and much dilated in the middle, concolorous with the body, becoming dusky at tip; transparent, the liquid globules being seen. Style about one-third as long as the honey-tubes, yellowish. Body all green, with some mottlings of deeper color above. Legs very long and slender, all green except tips of tibiæ and the tarsi, black. Length of body about 3^{mm}, or slightly more.

This large and interesting species was found feeding on the fronds of *Onoclea struthiopteris* or ostrich-fern. It agrees in all respects with Buckton's description and figure of *Amphorophora ampullata*, and I doubt not that they are identical. The length of the antennæ, together with the distinct frontal tubercles, may justify our exception of Amphorophora as a good genus, but at present I am unable to break up the genus Rhopalosiphum as given by Koch, so as to get anything like satisfaction out of it.

Genus MACROSIPHUM Oestlund, 1886.

Antennæ as long or longer than the body, on moderately large frontal tubercles, but these not as approximate as in the next genus. Prothorax well developed, and with a distinct lateral tubercle. Wings rather long, clouded near the apex. Legs long and slender. Honey-tubes very long, much dilated in the middle, curved. Style long and conspicuous.

In my last report I proposed this genus for the elegant species found on the wild raspberry. It may be too close to Rhopalosiphum, when this genus is taken in its widest sense, but still it is as distinct from the more typical species of Rhopalosiphum, as *nympææ* or *rhois*, as any of the species of Nectarophora. The species *Rhopalosiphum dianthi* and *nabali* are intermediate forms between that genus and the present one.

1. Macrosiphum rubicola Oestl.

Macrosiphum rubicola Oestlund. Geol. and Nat. Hist. Surv. of Minn., 14th Rept., p. 27, 1886.

Antennæ as long or longer than the body, black, with the base of the third joint pale, this joint also more or less tuberculate; III 0.90^{mm}, IV 0.70^{mm}, V 0.55^{mm}, VI 0.15^{mm}, VII $0.90–1.10^{mm}$. Thorax with the lobes shining black; prothorax with a distinct lateral tubercle. Wings large; stigma long, broadest at the origin of the stigmal vein, dusky; at the apex of the fore wing there is a clouded patch between the stigmal and the cubital veins, extending slightly into the stigmal cell. Abdomen of a very pale color, whitish or greenish-white. Honey-tubes very long, about 1^{mm}, much dilated in the middle, slightly curved, transparent, slightly dusky. Style long, bent upward, of the same color as the abdomen. Length of body about 3^{mm}. Found on twigs and leaves of *Rubus strigosus*.

Genus NECTAROPHORA (Koch).*

Antennæ nearly always longer than the body, on distinct and approximate frontal tubercles; seventh joint mostly longer than the third. Prothorax with no lateral tubercle. Wings large.

*It is with some reluctance that I propose to replace a name that has already become so familiar and extensively used as that of Siphonophora. But Siphonophora as a generic term was already appropriated for the Myriapoda before Koch made use of it in the Aphididæ; and it is also used to denote an order of the oceanic Hydrozoa, and should, therefore, according to practice, be replaced by one not already occupied.

legs long and slender. Honey-tubes long and cylindrical. Style long, falchion-shaped.

Next to Aphis, one of the largest genus of the family, with the species all very much alike and difficult to separate. In habit they are also much like Aphis, found mostly in large colonies on herbaceous plants.

The species found in Minnesota may be separated in the following manner:

1	Color of body green, at least the abdomen.	2.
	Color some other than green.	10.
2	Apterous form pulverulent.	3.
	Apterous form not pulverulent.	5.
3	Style long, equal to the honey-tubes.	N. LUDOVICIANÆ.
	Style shorter than the honey-tubes.	4.
4	Honey-tubes not much longer than style; sensoria only on third joint.	N. FULVÆ.
	Honey-tubes more than twice the style in length; sensoria on joints 3–5.	N. GERANII.
5	Fourth joint of antennæ about one-half of the seventh in length.	N. CYNOSBATI.
	Fourth joint more than one-half of the seventh.	6.
6	Seventh joint of antennæ shorter or not longer than the third.	7.
	Seventh much longer than the third.	9.
7	Honey-tubes very long, black; sensoria on third joint alone.	N. ERIGERONENSIS.
	Honey-tubes not as long; sensoria on joints 3–4.	8.
8	Antennæ about as long as the body.	N. PURPURASCENS
	Antennæ much longer than body.	N. ROSÆ.
9	Beak moderately long; 0.40^{mm}.	N. CORYDALI.
	Beak long; 0.65^{mm}.	N. PISI.
10	Style more than one-half the honey-tubes in length.	11.
	Style one-half the honey-tubes or less.	13.
11	Eyes red; color of body pale brown.	N. PALLIDA.
	Eyes dark brown, or black.	12.
12	Larvæ smooth.	N. RUDBECKIÆ.
	Larvæ with the dorsum tuberculate.	N. AMBROSIÆ.
13	Style black; honey-tubes imbricated.	N. FRIGIDÆ.
	Style pale; honey-tubes smooth.	14.
14	Honey-tubes very long, more than twice the style.	S. POTENTILLÆ.
	Honey-tubes moderately long, not more than twice the style.	15.
15	Abdomen with a marginal row of impressed pits.	S. CHRYSANTHEMI.
	Abdomen with only a row of black dots.	S. GRANARIA.

1. Nectarophora fulvæ n. sp.

Antennæ longer than body; more or less dusky; III 0.60^{mm}, IV 0.50^{mm}, V 0.45^{mm}, VI 0.15^{mm}, VII 0.70^{mm}. Beak reaching beyond second coxæ, 0.40^{mm}. Head and thorax dark brown or black. Abdomen dark green. Honey-tubes short, not longer than style, 0.20^{mm}; dusky or black. Style stout, concolorous with abdomen, 0.20^{mm} long.

This peculiar species is found on *Impatiens fulva*. The larvæ are very pulverulent, so as to appear white; and the castings of these are very conspicuous when found on the plant.

Length of body 2^{mm}; to tip of wings 4.25^{mm}.

2. Nectarophora ludovicianæ (Oestl.).

Siphonophora ludovicianæ Oestl., Geol. Surv. Minn., 14th Rept., p. 23, 1886.

Antennæ longer than body, black; III 1^{mm}, IV 0.80^{mm}, V 0.65^{mm}, VI 0.20^{mm}, VII 1^{mm}. Beak long, 0.45^{mm}. Eyes of a brighter red than usual. Head and thorax blackish. Abdomen green, more or less pulverulent, as in the apterous form, which are much covered with a yellowish white substance, giving to them the same color and tomentous appearance as the plant. Honey-tubes black; slightly thicker at base, 0.50^{mm} long. Style very long, about as long as the honey-tubes, 0.50^{mm}, yellowish. Length of body 2.50^{mm}; to tip of wings 4.50^{mm}.

Found on *Artemisia ludoviciana*; a large and very active species. I have never found it numerous or in large colonies, as is usual in this genus.

3. Nectarophora geranii n. sp.

Antennæ much longer than body, slender; III 0.80^{mm}, IV 0.70^{mm}, V 0.70^{mm}, VI 0.20^{mm}, VII 1^{mm}. Head and thorax brownish, rest of body pale green. Wings yellow at base; veins rather prominent, brownish. Legs pale except the joints, and the tarsi black. Honey-tubes very long and slender, 0.90^{mm}, dusky, or becoming black. Style concolorous with abdomen, 0.25^{mm}. Length of body 2.25^{mm}; to tip of wings 4.50^{mm}.

Found on *Geranium maculatum* Linn., mostly on the stem and petioles of the upper leaves. The apterous form is covered with a fine white pulverulent substance, which gives them a glaucous

appearance. Joints four and five of the antennæ are mostly equal, or nearly so. Some winged males had joints III, IV and V equal (0.70^{mm}), and the last joint very long (1.25^{mm}).

4. Nectarophora cynosbati n. sp.

Antennæ longer than the body, dusky or black; III 0.75^{mm}, IV 0.45^{mm}, V 0.40^{mm}, VI 0.10^{mm}, VII 1^{mm}. Beak long, 0.60^{mm}. Head and thorax pale brown, or dusky, shining. Wings hyaline, second branch of the cubital nearer the apex than to the first branch. Legs pale except at joints. Abdomen uniformly green. Honey-tubes greenish, or becoming dusky towards the apex; 0.40^{mm} long. Style half as long as the honey-tubes, concolorous with the abdomen. Length of body 2^{mm}, or slightly over; to tip of wings 4.80^{mm}.

Found on the under side of the leaves and twigs of *Ribis cynosbati* Linn.

5. Nectarophora purpurascens n. sp.

Antennæ about as long as the body, or but slightly longer; III 0.70^{mm}, IV 0.50^{mm}, V 0.40^{mm}, VI 0.15^{mm}, VII 0.55^{mm}. Beak reaching second coxæ. Head and thorax shining black. Abdomen green. Honey-tubes pale at base, dusky above, 0.50^{mm} long. Style half as long as the honey-tubes, pale. Length of body 2.30^{mm}; to tip of wings 4.30^{mm}.

Found on *Thalictrum purpurascens* Linn. The larvæ change to the same purple color as the plant soon after they have been killed.

6. Nectarophora rosæ (Linn.).

Aphis rosæ Linn.
Siphonophora rosæ Koch.

Antennæ longer than body, black; III 1^{mm}, IV 0.90^{mm}, V 0.75^{mm}, VI 0.20^{mm}, VII 1.10^{mm}. Head and thorax shining black; abdomen green, with a marginal row of black dots and some transverse black bands above. Honey-tubes black, 0.60^{mm}. Style about half as long the honey-tubes. There is also a pale red or pinkish variety found on some of our wild roses. Length of body nearly 3^{mm}; to tip of wings 4.50^{mm}.

Found plentiful both on the cultivated and wild rose.

7. Nectarophora erigeronensis (Thos.).

Siphonophora erigeronensis Thos. Bull. Ill. St. Lab. Nat. Hist., No. 2, p. 7, 1878.

Antennæ a little longer than the body, dusky except at base; III 0.70^{mm}, IV 0.60^{mm}, V 0.50^{mm}, VI 0.15^{mm}, VII 0.70^{mm}. Beak long. Head and thorax of a deeper and somewhat more shining green than the abdomen. Legs long and slender, black except basal half of the femora. Abdomen of uniform green. Honey-tubes very long, 0.80^{mm}, black. Style nearly half the honey-tubes in length, concolorous with abdomen.

This very common and plentiful species is found on *Erigeron canadense* Linn.

8. Nectarophora corydalis (Oestl.).

Siphonophora corydalis Oestl. Geol. Surv. Minn., 14th Rept., p. 25, 1886.

Antennæ longer than the body, black; III 0.90^{mm}, IV 0.75^{mm}, V 0.70^{mm}, VI 0.20^{mm}, VII 1.20^{mm}. Beak 0.40^{mm}. Head and thorax very smooth and shining, yellowish. Abdomen green. Honey-tubes long, 0.60^{mm}; more or less dusky, green at base. Style at least half as long as the honey-tubes, concolorous with abdomen.

Found on *Corydalis aurea* Willd.

9. Nectarophora pisi (Kalt.).

Antennæ much longer than the body, pale or only tips slightly dusky; III 0.90^{mm}, IV 0.75^{mm}, V 0.70^{mm}, VI 0.20^{mm}, VII 1.10^{mm}. Beak long, 0.65^{mm}. Head and thorax olive brown; abdomen pale green. Honey-tubes green, 0.90^{mm} long. Style long, 0.45^{mm}, concolorous with abdomen.

A very common species found on *Capsella bursa-pastoris*, *Urtica gracilis* Ait., and other garden plants and weeds.

10. Nectarophora granaria (Kirby).

Aphis granaria Kirby.
Aphis hordei Kyber.
Aphis cerealis Kalt.
Aphis avenæ Fitch.
Siphonpohora cerealis Koch, Kalt., Pass.
Siphonophora avenæ Thomas.
Siphonophora granaria Walk., Buckt., Monell.

Antennæ about as long as the body or a little longer, black; III 0.60^{mm}, IV 0.50^{mm}, V 0.40^{mm}, VI 0.15^{mm}, VII 0.65^{mm}. Head and thorax of a dark brown; abdomen of a paler reddish-brown, or green in the early brood found on the leaves. Honey-tubes black, about 050^{mm}. long. Style about one-half as long. This species is found on cultivated wheat and oats, as well as on several species of grasses.

11. Nectarophora potentillæ n. sp.

Antennæ longer than body, black; III 0.80^{mm}, IV 0.65^{mm}, V 0.50^{mm}, VI 0.15^{mm}, VII 0.85^{mm}?. Beak long and stout, 0.60^{mm}. Head and thorax shining pale brown. Wings with narrow veins; second branch midway. Abdomen of a very pale brown color, somewhat darker in the middle and along the margins. Honey-tubes concolorous with the abdomen, about 0.60^{mm} long. Style rather short, not more than 0.20^{mm} long, pale. Length of body 2.60^{mm}; to tip of wings 5^{mm}.

Found on the under side of the leaves of *Potentilla anserina*. Comes nearest to the brownish variety of N. rosæ, but is much paler, and the style shorter.

12. Nectarophora frigidæ (Oestl.).

Siphonophora frigidæ Oestl. Geol. Surv. Minn., 14th Rept., p. 20, 1886.

Antennæ about as long as the body, black; III 0.60^{mm}, IV 0.45^{mm}, V 0.40^{mm}, VI 0.15^{mm}, VII 0.50^{mm}. Beak long, 0.60^{mm}. Head and thorax of a deep black; abdomen of a shining dark green, with a metallic lustre. Honey-tubes black, 0.40^{mm} long. Style about half as long, black. Length of body 2.30^{mm}; to tip of wings 4^{mm}.

This peculiar species is found on *Artemisia frigida*, as growing on the bluffs of the Mississippi river near the falls of St. Anthony. In the preceding report I described the apterous male of this species, which has again repeatedly been observed in addition to the winged male. What the economy of the wingless male is we do not know, nor why the two forms should be found in the same species; but which is a fact observed not only in this, but also in several other cases.

13. Nectarophora chrysanthemi (Oestl.).

Siphonophora chrysanthemi Oestl. Geol. Surv. Minn., 14th Rept., p. 22, 1886..

Antennæ about as long as the body, all black; III 0.70^{mm}, IV 0.55^{mm}, V 0.45^{mm}, VI 0.10^{mm}, VII 0.80^{mm}. Beak at least 0.60^{mm} long. Head and thorax of a deep shining black; abdomen of a somewhat duller dark brown, with a row of impressed pits on each side. Honey-tubes shining black, about 0.50^{mm} long; style half as long, pale. Length of body about 2.25^{mm}.

Found on the upper stalks and flower heads of *Bidens chrysanthimoides* Mx.

14. Nectarophora pallida n. sp.

Antennæ much longer than the body, black; only third joint with sensoria; III 1.10^{mm}, IV 0.90^{mm}, V 0.75^{mm}, VI 0.20^{mm}, VII 1.10^{mm}. Beak long, 0.70^{mm}. Head and thorax of a pale olive brown, shining; abdomen of a very pale reddish or pinkish color, with the young embryos visible. Eyes reddish brown, much paler than usual in this genus. Honey-tubes large, thickest at base; black, or usually somewhat paler at base; about 0.90^{mm} long. Style very large and stout, at least half as long as the honey-tubes, yellowish. Length of body 2.50–3^{mm}; to tip of wings 5^{mm}.

This large species, as found on the wild rose, appears to be distinct from the green species found on the same plant. The apterous viviparous female is usually 3^{mm} long, or sometimes even longer. Antennæ somewhat longer than above; honey-tubes 1^{mm}, black; style half as long.

15. Nectarophora ambrosiæ (Thos.).

Siphonophora ambrosiæ Thomas. Bull. Ill. St. Lab. Nat. Hist., 2, p. 4, 1878.

Antennæ somewhat longer than the abdomen; III 0.90^{mm}, IV 0.75^{mm}, V 0.65^{mm}, VI 0.15^{mm}, VII 1^{mm}. Beak about 0.75^{mm} long. Whole insect of a rather dark brown; in winged form smooth and shining, but in apterous with the dorsum tuberculate. Honey-tubes about 0.75^{mm} long, black; style stout, at least half as long as the honey-tubes, or longer; paler in color than abdomen. Length of body 2.75^{mm}; to tip of wings 4.75^{mm}.

Found in great numbers on *Ambrosia trifida* Linn., and *psilostachya*. Similar to *N. rudbeckiæ* in size and habit, and with it subject to a great amount of variations. The only well-marked difference, beside color, seems to be in the tuberculate dorsum of the larvæ.

16. Nectarophora rudbeckiæ (Fitch).

Aphis rudbeckiæ Fitch. Cat. Hom. N. Y. St. Cab., p. 66, 1851.
Siphonophora rudbeckiæ Thomas. Bull. Ill. St. Lab. Nat. Hist., 2, p. 4, 1878.

Antennæ much longer than the body, black, with the base paler; III 0.95^{mm}, IV 0.80^{mm}, V 0.70^{mm}, VI 0.18^{mm}, VII $1.^{mm}$, Beak long, about 0.90^{mm}. Body bright red; head and thorax of nearly the same shade, or but slightly darker. Honey-tubes long, about 0.85^{mm}, shining black. Style at least half the honey-tubes in length or longer (0.50^{mm}), paler than abdomen. Wings with yellow insertions.

This bright red variety, as found on *Silphium perfoliatum* and other composite plants, I consider as the typical *rudbeckiæ*.

The following Nectarophorini have been recorded as American, but not yet found in Minnesota:

Rhopalosiphum berberidis (Kalt.), found on the under side of the leaves of barberry.

Rhopalosiphum tulipæ Thomas, found on *Tulipa gesneriana*.

Myzus persicæ (Sulz.), the peach tree aphis.

Phorodon humili (Schrank), on the hop.

Phorodon mahaleb (Fonsc.), has been found, according to Monell, at St. Louis.

Phorodon scrophulariæ Thomas, on what was supposed to be *Scrophularia nodosa* (Thomas).

Nectarophora euphorbiæ (Thomas), found on *Euphorbia; N. euphorbicola* of the same writer is probably but a variety.

Nectarophora lactucæ (Kalt.), occasionally found on garden lettuce.

Nectarophora polygoni (Walk.) found on *Polygonum persicaria*.

Nectarophora verbenæ (Thomas), on the leaves of *Verbena*.

Nectarophora rubi (Kalt.), found on blackberry. What Thomas has identified as this species is probably but an immature form of *Macrosiphum rubicola*.

Nectarophora lilii (Monell), found on *Lilium*.

Nectarophora calendulella (Monell), on the under side of leaves of *Calendula micrantha*.

Nectarophora tulipæ (Monell), on the petals and stigma of tulips.

Nectarophora tiliæ (Monell), on the under side of the leaves of linden, causing them to curl.

Nectarophora liriodendri (Monell), on *Liriodendron tulipifera*.

Nectarophora cratægi (Monell), on the under side of the leaves of *Cratægus coccinea.*
Nectarophora sonchi (Linn.), on *Sonchus oleracea.*
Nectarophora calendulæ (Monell), on *Calendula micrantha.*
Nectarophora fragariæ immaculata (Riley), on the strawberry.
Nectarophora gerardiæ (Thomas), on *Gerardia tenuifolia.*
Nectarophora heucheræ (Thomas), on *Heuchera hispida.*
Nectarophora cucurbitæ (Thomas), on the leaves of squash vines.
Nectarophora citrifolii (Ashmead), on orange.
Nectarophora prunicola (Ashmead).
Nectarophora solanifolii (Ashmead), on *Solanum jasminoides.*
Nectarophora minor (Forbes).

LIST OF NORTH AMERICAN PLANTS WITH THE SPECIES OF APHIDES KNOWN TO ATTACK THEM.

Alder (Alnus rubra).
 Pemphigus tesselata (Fitch).
 Lachnus alnifoliæ Fitch.
Alum root (Heuchera hispida).
 Nectarophora heucheræ (Thomas).
Amarantaceæ (Achyrantes).
 Myzus achyrantes (Monell).
American larch. See larch.
Apple. Cultivated.
 Schizoneura lanigera (Hausm.).
 Callipterus mucidus Fitch.
 Aphis mali Fab.
Ash (Fraxinus americana, sambucifolia and quadrangulata).
 Pemphigus fraxinifolii Riley.
Aspen (Populus tremuloides). See poplar.
Aster.
 Aphis middletonii Thomas (roots).

Balsam poplar (Populus balsamifera). See poplar.
Barberry (Berberis vulgaris).
 Rhopalosiphum berberidis (Kalt.).
Barley. Cultivated.
 Nectarophora granaria (Kirby).
Basswood (Tilia americana).
 Lachnus longistigma Monell.
 Nectarophora tiliæ (Monell).
Bean. Cultivated.
 Aphis rumicis Linn.

Bedstraw (Galium aparine).
    Aphis aparines Koch.
        (Galium circæzans.)
    Aphis circæzandis Fitch.
Beech (Fagus).
    Phyllaphis fagi (Linn.).
    Schizoneura imbricator (Fitch).
Bidens. See bur-marigold.
Birch (Betula papyracea).
    Hormaphis papyraceæ Oestl.
    Callipterus betulæcolens (Fitch).
Bitternut hickory (Carya amara). See hickory.
Blackberry.
    Sipha rubifolii Thos.
    Nectarophora rubi (Kalt.).
Black Cherry (Prunus serotina). See Cherry.
Box elder (Negundo aceroides).
    Chaitophorus negundinis Thos.
Bur-marigold (Bidens chrysanthimoides).
    Nectarophora chrysanthemi (Oestl.).
    Nectarophora rudbeckiæ (Fitch).
        (Bidens frondosa).
    Aphis frondosæ Oestl.
Bur oak (Quercus macrocarpa). See oak.
Button-bush (Cephalanthus occidentalis).
    Aphis cephalanthi Thos.

Cabbage (Brassica oleracea).
    Aphis brassicæ Linn.
Calendula micrantha.
    Aphis calendulicola Monell.
    Nectarophora calendulæ (Monell).
    Nectarophora calendulella (Monell).
Caragana arborescens.
    Aphis medicaginis Koch.
Carnation pink.
    Rhopalosiphum dianthi (Schr.).
Chenapodiaceæ.
    Aphis atriplicis Linn.
    Aphis rumicis Linn.
Cherry. Cultivated.
    Myzus cerasi (Fab.).
        (Prunus serotina).
    Aphis cerasicolens Fitch.
        (Prunus virginiana).
    Aphis crasifoliæ Fitch.
Choke cherry (Prunus virginiana). See cherry.
Chestnut (Castanea vesca).

Chestnut Phylloxera castaneæ (Hald.).
    Callipterus castaneæ Fitch.
Clover (Trifolium).
    Callipterus trifolii Monell.
        (Trifolium repens).
    Aphis trifolii Oestl. (roots).
Cocle-bur (Xanthium canadense).
    Siphocoryne xanthii Oestl.
Common brake (Pteris aquilina).
    Mastopoda pteridis Oestl.
Cone-flower (Rudbeckia laciniata).
    Nectarophora rudbeckiæ (Fitch).
Corn. Cultivated.
    Aphis maidis Fitch.
Cornel. See dogwood.
Corydalis aurea.
    Nectarophora corydalis (Oestl.).
Cotton. Cultivated.
    Aphis gossypii Glover.
Cottonwood (Populus monilifera). See poplar.
Cranberry-tree (Viburnum opulus).
    Aphis viburni Scop.
Crab-apple.
    Aphis mali Fab.
Cranebill (Geranium maculata).
    Nectarophora geranii Oestl.
Cucumber. Cultivated.
    Aphis cucumeris Forbes.
Cup-plant (Silphium perfoliatum and intigrifolia).
    Nectarophora rudbeckiæ (Fitch).
Currant. Cultivated.
    Myzus ribis (Linn.).

Dock (Rumex).
    Aphis rumicis Linn.
Dogbane (Apocynum cinnabinum).
    Aphis asclepiadis Fitch.
    Aphis apocyni Koch.
Dogwood (Cornus florida).
    Aphis cornifoliæ Walsh.
        (Cornus paniculata).
    Aphis cornifoliæ Walsh.
    Aphis maculata Oestl.
    Schizoneura corni Fab.
        (Cornus stolanifera).
    Schizoneura cornicola Walsh.

Elder (Sambucus).

Elder Aphis sambucifoliæ Fitch.
(Aphis sambuci Linn.?)
Eleusine indica.
Rhizobius eleusinis Thos. (roots).
Elm (Ulmus americana).
Tetraneura ulmi (Linn.).
Colopha ulmicola (Fitch).
Schizoneura americana Riley.
Schizoneura rileyi Thomas.
Callipterus ulmifolii Monell.
(Ulmus fulva).
Pemphigus ulmifusus (Walsh).
Evening primrose (Œnothera biennis).
Aphis œnothera Oestl.
Eupatorium (Eupatorium perfoliatum).
Aphis eupatorii Oestl.
(Eupatorium agerotoides).
Aphis agerotoidis Oestl.

Fern (Adiatum pedatum).
Aphis adianti (Oestl.).
(Onoclea struthiopteris).
Rhopalosiphum ampullata (Buckt.).
(Pteris aquilina).
Mastopoda pteridis Oestl.
Figwort (Scrophularia nodosa).
Phorodon scrophulariæ Thos.
Fleabane (Erigeron canadense).
Tychea erigeronensis Thos. (roots).
Aphis middletonii Thos. (roots).
Nectarophora erigeronensis (Thos.).
Fungus.
Schizoneura fungicola (Walsh).

Galium. See bedstraw.
Gerardia tenuifolia.
Nectarophora gerardiæ (Thos.).
German ivy.
Rhopalosiphum dianthi (Schr.).
Golden rod (Solidago serotina and rigida).
Siphocoryne serotinæ Oestl.
Nectarophora rudbeckiæ (Fitch).
Gooseberry (Ribis cynosbati).
Nectarophora cynosbati Oestl.
Goosefoot (Chenopodiaceæ).
Aphis atriplicis Linn.
Aphis rumicis Linn.

Grapevine. Cultivated.
    Phylloxera vitifoliæ (Fitch).
    Nectarophora viticola (Thos.).
        (Vitis riparia).
    Aphis ripariæ Oestl.
Grasses (Agrostis plumosa).
    Tetraneura graminis Monell.
        (Aira cæspitosa).
    Tetraneura graminis Monell.
        (Eragrostis poæoides).
    Colopha eragrostidis Middleton.
        (Panicum crusgalli).
    Aphis setariæ (Thos.).
        (Panicum glabrum).
    Tychea panici Thomas (roots).
    Schizoneura panicola Thos. (roots).
        (Phalaris canariensis).
    Nectarophora granaria (Kirby).
        (Poa annua).
    Rizobius poæ Thos. (roots).
    Aphis annuæ Oestl.
    Nectarophora granaria (Kirby).
        (Setaria glauca).
    Aphis setariæ (Thos.).
Great angelica (Archangelica atropurpurea).
    Siphocoryne archangelicæ Oestl.
Great-toothed poplar (Populus grandidentata). See poplar.

Hawthorn (Cratægus coccinia).
    Nectarophora cratægi (Monell).
        (Cratægus punctata).
    Schizoneura cratægi Oestl.
    Aphis cratægifolia Fitch.
Helianthus. See sunflower.
Hickory (Carya).
    Phylloxera caryæcaulis (Fitch).
    Phylloxera caryæglobosa Shimer.
    Phylloxera caryævenæ (Fitch).
    Phylloxera conica (Shimer).
    Phylloxera forcata (Shimer.)
    Schizoneura caryæ (Fitch).
    Lachnus caryæ Harris.
    Callipterus caryæ Monell.
        (Carya alba).
    Phylloxera caryæfoliæ (Fitch).
    Phylloxera caryæfallax Riley.
    Phylloxera caryæglobuli Walsh.
    Phylloxera caryægummosa Riley.

Hickory (Carya alba).
    Phylloxera caryæsepta (Shimer).
    Phylloxera depressa (Shimer).
        (Carya amara).
    Phylloxera spinosa (Shimer).
    Monella caryella (Fitch).
        (Carya glabra).
    Phylloxera caryæglobuli Walsh.
    Phylloxera caryæren Riley.
    Phylloxera caryæsemen (Walsh).
High cranberry. See cranberry tree.
Honey-suckle (Lonicera glauca).
    Aphis loniceræ Monell.
Hop (Humulus lupulus).
    Phorodon humuli (Schr.).
Horse-mint (Monarda fistulosa).
    Aphis monardæ Oestl.

Indian plantain (Cacalia suaveolens).
    Nectarophora rudbeckiæ (Fitch).
Ironweed (Vernonia fasiculata).
    Aphis middletonii Thos. (roots).
    Aphis vernoniæ Thos.
    Nectarophora rudbeckiæ (Fitch).

Knotweed (Polygonus persicaria).
    Nectarophora polygoni (Walk.).

Larch (Larix americana).
    Chermes laricifoliæ Fitch.
    Lachnus laricifex Fitch.
Leguminosæ.
    Aphis medicaginis Koch.
Lettuce. Cultivated.
    Rhizobius lactucæ Fitch (roots).
    Nectarophora lactucæ (Kalt.).
Lily (Lilium).
    Nectarophora lilii (Monell).
Linden. See basswood.
Liriodendron. See tulip-tree.

Maidenhair (Adiantum pedatum).
    Aphis adianti (Oestl.).
Mallow (Malva rotundifolia).
    Myzus achyrantes (Monell).
Maple (Acer dasycarpum).
    Drepanosiphum acerifolii (Thos.).
    Pemphigus acerifolii Riley.

Maple (Acer pennsylvanicum).
Chaitophorus aceris (Linn.).
(Acer saccharinum).
Pemphigus aceris Monell.
May-weed (Maruta cotula).
Aphis marutæ Oestl.
Meadow-parsnip (Thaspium aureum).
Aphis thaspii Oestl.
Meadowrue (Thalictrum purpurascens).
Nectarophora thalictri Oestl.
Meadow-sweet (Spiræa salicifola).
Aphis spirææ Oestl.
Melilotus italica.
Aphis medicaginis Koch.
Melon. Cultivated.
Aphis cucumeris Thos.
Milk-weed (Asclepias cornuti).
Aphis asclepiadis Fitch.
Callipterus asclepiadis Monell.
(Asclepias obtusifolia).
Callipterus asclepiadis Monell.
(Asclepias syriaca).
Aphis lutescens Monell.
Monkey-flower (Mimulus jamesii).
Aphis mimuli Oestl.
Mountain ash (Pyrus americana).
Aphis mali Fab.
Mustard (Senapis nigra).
Aphis brassicæ Linn.

Nabalus albus. See white lettuce.
Nettle (Urtica gracilis).
Nectarophora pisi (Kalt.).
Nine-bark (Neillia opulifolia).
Aphis neilliæ Oestl.

Oak (Quercus).
Schizoneura querci (Fitch).
Callipterus quercicola Monell.
Aphis quercifoliæ Walsh.
(Quercus alba).
Phylloxera rileyi Licht.
Lachnus quercifoliæ Fitch.
(Quercus bicolor).
Phylloxera rileyi Licht.
Callipterus discolor Monell.
Callipterus punctatus Monell.

Oak (Quercus imbricaria).
    Callipterus hyalinus Monell.
        (Quercus macrocarpa).
    Chaitophorus spinosa Oestl.
    Callipterus discolor Monell.
        (Quercus obtusiloba).
    Phylloxera rileyi Licht.
        (Quercus phellos laurifolia).
    Phyllaphis niger Ashmead.
        (Quercus prinus).
    Chaitophorus quercicola Monell.
        (Quercus rubra).
    Callipterus bellus (Walsh.).
        (Quercus virens).
    Lachnus quercicolens Ashmead.
Oats. Cultivated.
    Nectarophora granaria (Kirby).
Oleander (Nerium oleander).
    Aphis nerii Kalt.
Orange (Citrus).
    Aphis citri Ashmead.
Ostrich-fern (Onoclea struthiopteris).
    Rhopalosiphum ampullata (Buckt.).
Oxybaphus angustifolius.
    Aphis oxybaphi Oestl.
Pea. Cultivated.
    Nectarophora pisi Linn.
Peach. Cultivated.
    Myzus persicæ (Sulz.).
Pecan.
    Callipterus caryæ Monell.
Persimmon (Diospyros virginiana).
    Aphis diospyri (Thos.).
Pigweed (Chenopodium).
    Aphis rumicis Linn.
Pine (Pinus).
    Chermes pinicorticis (Fitch).
    Lachnus australi Ashmead.
    Chaitophorus pinicolens (Fitch).
        (Pinus strobus).
    Schizoneura pinicola Thos.
    Lachnus strobi Fitch.
Plum. Cultivated.
    Aphis pruni Koch.
    Myzus persicæ (Sulz.).
    Nectarophora prunicola (Ashmead).
Polanisia (Polanisia graveolens).
    Aphis polanisiæ Oestl.

Poplar (Populus balsamifera).
    Pemphigus popularius Fitch.
    Pemphigus populiglobuli Fitch.
    Pemphigus populivenæ Fitch.
    Pemphigus populiramulorum Riley.
    Pemphigus populitransversus Riley.
        (Populus balsamifera angustifolia).
    Pemphigus populimonilis Riley.
        (Populus grandidentata).
    Aphis populifoliæ Fitch.
        (Populus monilifera and angulata).
    Phylloxera prolifera Oestl.
    Pemphigus populicaulis Fitch.
    Pemphigus populitransversus Riley.
    Pemphigus pseudobyrsa (Walsh).
    Pemphigus vagabundus (Walsh).
    Chaitophorus populicola Thos.
Pot marigold. See calendula.

Ragweed (Ambrosia psilostachya).
    Nectarophora ambrosiæ (Thos.).
        (Ambrosia trifida).
    Tychea radicola Oestl. (roots).
    Aphis middletonii Thos. (roots).
    Nectarophora rudbeckiæ (Fitch).
Raspberry (Rubus occidentalis).
    Pemphigus rubi Thos.
        (Rubus strigosus.)
    Aphis rubicola Oestl.
    Macrosiphum rubicola Oestl.
Red elm (Ulmus fulva). See elm.
Red oak (Quercus rubra). See oak.
Reed (Phragmites communis).
    Hyalopterus arundinis (Koch)
Robinia viscosa.
    Aphis medicagenis Koch.
Rose. Cultivated.
    Nectarophora rosæ (Linn.).
        (Wild).
    Myzus rosarum (Walck).
    Nectarophora pallida Oestl.

Scrophularia nodosa.
    Phorodon scrophulariæ Thos.
Shag-bark hickory (Carya alba). See hickory.
Shepherd's purse (Capsella bursa-pastoris).
    Aphis rumicis Linn.
    Nectarophora pisi (Kalt.).

Silver-weed (Potentilla anserina).
    Myzus rosarum (Walck).
    Nectarophora potentillæ Oestl.
Snowball (Viburnum opulus roseum).
    Aphis viburni Scop.
Snowberry (Symphoricarpus vulgaris).
    Aphis albipes Oestl.
    Aphis symphoricarpi Thos.
Solanum jasminoides.
    Nectarophora solanifolii (Ashmead).
Sorghum. Cultivated.
    Chaitophorus flavus Forbes.
Sow-thistle (Sonchus oleraceus).
    Rhopalosiphum dianthi (Schr.).
    Nectarophora rudbeckiæ (Fitch).
    Nectarophora sonchi (Linn.).
    Nectarophora sonchella (Monell).
Spruce (Abies nigra and alba).
    Chermes abieticolens Thos.
    Chermes abietis (Linn.).
    Lachnus abietis Fitch.
Spurge (Euphorbia marginata).
    Nectarophora euphorbicola (Thos.).
        (Euphorbia maculata.)
    Nectarophora euphorbiæ (Thos.).
Squash-vines.
    Aphis cucumeris (Forbes).
    Nectarophora cucurbitæ (Thos.).
St. Johnswort (Hypericum kalmianum).
    Aphis hyperici Monell.
        (Hypericum prolificum).
    Callipterus hyperici (Thos.).
Strawberry (Fragaria).
    Nectarophora fragariæ immaculata (Riley).
    Nectarophora minor (Forbes).
Sumach (Rhus glabra).
    Pemphigus rhois Fitch.
    Rhopalosiphum rhois Monell.
Sun-flower (Helianthus).
    Aphis helianthi Monell.
Sycamore (Platanus).
    Lachnus platanicola Riley.
Symphoricarpus. See snowberry.

Tamarack. See larch.
Thistle (Circium).
    Aphis carduella (Walsh).
    Aphis cardui Fab.
    Nectarophora rudbeckiæ (Fitch).

Thorn. See hawthorn.
Tickseed (Coreopsis aristosa).
    Aphis coriopsidis (Thos.).
Tomato. Cultivated.
    Rhopalosiphum solani (Thos.).
Touch-me-not (Impatiens fulva).
    Aphis impatientis Thos.
    Nectarophora fulvæ Oestl.
Tulip (Tulipa gesneriana).
    Rhopalosiphum tulipæ Thos.
    Nectarophora tulipæ (Monell).
Tulip-tree (Liriodendron tulipifera).
    Nectarophora liriodendri (Monell).

Vervain (Verbena).
    Nectarophora verbenæ (Thos.).
Virginia creeper (Ampelopsis quinquifolia).
    Aphis setariæ (Thomas).

Walnut (Juglans).
    Schizoneura caryæ (Fitch).
    Callipterus caryæ Monell.
Wheat. Cultivated.
    Nectarophora granaria (Kirby).
White elm. See elm.
White lettuce (Nabalus albus).
    Rhopalosiphum nabali Oestl.
White oak (Quercus alba). See oak.
White pine (Pinus strobus). See pine.
White snake-root (Eupatorium agerotoides). See eupatorium.
Willow (Salix).
    Aphis salicicola (Thos.).
    Melanoxanthus salicis (Linn.).
    Melanoxanthus salicti (Harris).
    Melanoxanthus bicolor Oestl.
    Lachnus salicellis Fitch.
    Lachnus viminalis Fonsc.
    Chaitophorus nigræ Oestl.
    Chaitophorus viminalis Monell.
    Siphocoryne salicis (Monell).
Witch-hazel (Hamamelis virginiana).
    Hormaphis hamamelidis (Fitch).
    Hormaphis spinosus (Shimer).
Worm-wood (Artemisia frigida).
    Aphis frigidæ Oestl.
    Nectarophora frigidæ Oestl.
        (Artemisia ludoviciana.)
    Nectarophora ludovicianæ Oestl.

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Synonyms are printed in *italics*.

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GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

N. H. WINCHELL, STATE GEOLOGIST.

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NATURAL GAS IN MINNESOTA.

From

BY N. H. WINCHELL.

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NATURAL GAS IN MINNESOTA.

A HISTORY OF FACTS, AND A STATEMENT OF GEOLOGICAL PRINCIPLES.

The great discoveries of gas in Pennsylvania and more recently in Ohio and Indiana, and in other places in the United States, have had their natural effect in Minnesota. They have caused a feverish and sometimes an expressed feeling of unrest, and of curiosity to know what would be the result in case a careful probing of the earth's crust were undertaken. They have caused a re-examination of old records, and a restatement of all the nearly forgotten incidents which occurred years ago which could be interpreted as indications of natural gas at numerous places in the state. They have sharpened the observation of all well-drillers and others who in any way could be considered to be in situations such as might reveal evidences of escaping gas. The human eye-sight, the sense of smell, the love of lucre, the knowledge of geology, the ignorance of all geologists, have received a sudden and very general popular increment. These have had their influence on our Legislature. This is all very natural and not at all blameworthy. The demand for public expenditure in search for the hidden resources of the state, when the commonwealth in general is interested in the enterprise, is a demand that should be heeded by legislators. It is one of the distinguishing marks of American civilization that the people are willing to tax themselves for the promotion of public improvements and for scientific research. The people in general are more intimately acquainted with as well as more profoundly interested in the prosecution of scientific research, and the economic results of such research, than in other civilized countries.

This general impulse toward economic geology in Minnesota resulted in the passage of the following law by the Legislature of 1887.

AN ACT TO EXTEND THE WORK OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF THE STATE.

Be it enacted by the Legislature of the State of Minnesota.

SECTION 1. It shall be the duty of the state geologist to make practical and actual tests by drilling or digging or other excavations in the earth such as he shall deem best suited to accomplish the purpose of this act for the discovery of any of the hidden mineral resources of the state, such as iron, copper, silver, gold, coal, gas, coal oil, common salt or any other valuable material that he may deem likely to exist in any of the rock strata of this state.

SECTION 2. In determining the localities at which such testing and exploring shall be done he shall be guided by such geological facts as he may possess or obtain, which may indicate the existence of any of the substances which it is the purpose of this act to discover. He shall also be guided by the proportionate amount of money that the owner or owners of the land on which such explorations may be proposed shall contribute to pay the cost of such exploration.

SECTION 3. It shall be the duty of the state geologist to report at once to the board of regents all discoveries either of economic or scientific interest to the state that may be made by such testing and exploration. Each report shall be published by the board of regents in the same manner as now provided for the publication of the annual reports of the geological and natural history survey of the state, and shall be paid for out of the same fund. *Provided*, that any important mineral discoveries or other scientific contribution to the geological and natural history survey that the said state geologist may deem necessary for immediate publication, shall not be suppressed until the regular report of the board of regents, but shall be issued from time to time under the direction of said state geologist.

SECTION 4. That the sum of five thousand (5,000) dollars for the year A. D. one thousand eight hundred and eighty-seven (1887) and the sum of five thousand (5,000) dollars for the year A. D. one thousand eight hundred and eighty-eight (1888) is hereby appropriated out of any moneys not otherwise appropriated for the purpose of defraying the expenses of said tests. The investigations provided for in this act shall not be conducted in the interest of any mining company or corporation.

SECTION 5. This act shall take effect and be in force from and after its passage.

Approved March 8th, 1887.

In pursuance of the requirements of this law some investigations have been made, and it is the intention of the writer herewith to make report thereon so far as they have appertained to search for natural gas.

FACTS KNOWN PRIOR TO THE PASSAGE OF THE ABOVE LAW.

It will be a natural introduction to what follows relating to the investigations that have been carried on, to recall some of the considerations, and mention some of the facts which seemed to invite the expenditure of money in search of natural gas.

1. From time to time reports have been published of the sudden outburst of gas of some sort from excavations made by railroads or by private parties, either in digging common wells or in sinking drilled holes into the rocky strata.

In the making of a well near Big Stone lake the workmen of the Chicago, Milwaukee and St. Paul Railroad met with curious manifestations. There were slight explosions, accompanied by strong odors of some gas. The substance excavated at the bottom of the well was a dark damp clay. Finally a more severe and nearly a disastrous explosion, which threw the workmen violently back and against the side of the excavation, alarmed them so that the work ceased. In this case Supt. C. H. Pryor sent a quantity of the dark clay to the writer, reporting the circumstances and asking a solution of the trouble. The clay proved to be some of the carbonaceous shale of the Benton (probably) of the Cretaceous, and there seems to be little room for doubt that the gas originated in the lignitic beds of the Cretaceous.

In Traverse county, in Arthur, a large flow of gas was encountered at 180 feet depth, said to be below the till sheet of the drift. It rushed out with such force as "to throw out a heavy iron bolt inserted in the pipe." This was on the land of James H. Flood. This flow of gas continued but a short time, and gradually diminished, and finally ceased. This account is taken from the newspaper reports. The quality of the gas was not ascertained, so far as known.

Similar facts were reported by Mr. Francis Bossard from near Waseca. Two wells on his farm gave abundant evidences of gas escaping from the earth. They are about 65 feet deep, and at the mouth of the well the gas took fire from a lighted match and burned with a blue flame extending 8 or 10 feet in the air. When burning there was a noise which could be heard, as alleged, a mile and a half, and the earth trembled "as if by heavy thunder." Water from these wells has a bluish color, and when left to stand shows an oily scum on its surface. This is in a region supposed to be likely to have the Cretaceous rocks underlying the drift.

Mr. August Peterson reported signs of gas at the mouth of the Cannon river in Goodhue county. This was in the sinking of a drill for the purpose of artesian water. "At the depth of 85 feet there was an upheaval of sand and gravel, marked and forcible; filling the pipe to the hight of twenty feet with sand, packing it so tightly that we had to drill it out. After cleaning it out there was another upheaval, sending the gravel and sand thirty feet, and so it kept on. We worked a month on twenty-five feet. Whenever we got within 8 or 10 feet of the bottom of the pipe, up the gravel would come. At 115 feet we got the pipe clean, I think. The last cleaning out, however, showed a considerable yellow sand which looked as though coated with mustard; the very last, however, being a brown or blackish and oily substance which on being poured out separated from the water, a smoke or steam rising from it. Then we sent the drill down again, fully believing we were to the rock. The drill, weighing 1,500 pounds, was sent up about 15 feet in the pipe, and the sand the whole length of the drill, which is 28 feet, and shut the drill in solid, requiring several hours of work to loosen it. The parties working becoming both discouraged and angry, the thermometer ranging in the thirties (minus — N. H. W.), in extremity they procured a pile-driver and bent the pipe, so we left the place."

Making another trial at 100 feet from this place, toward the main river bluff, Mr. Peterson obtained a fine flowing well of pure water without any trouble, at the depth of 350 feet.

Besides the above statements there were rumors of the discovery of gas in several other places in the state, which could hardly be said to have authentic foundation. Some were at Hastings, at St. Paul, at Minneapolis, at points between Fort Snelling and Minneapolis, in Chisago county and at Stillwater.

2. About the same time some "experts" from the great gas regions of Pennsylvania, said to be perfectly familiar with the manner of occurrence of gas, and its geological relations to the rocks in which it is found, who could see the "first sandstone" and imagined they could see the "second sandstone" but a few hundred feet deeper, along the valley of the Mississippi in the vicinity of Minneapolis, lighted the flame of popular confidence in the certainty of gas in Minnesota in paying quantities, by confident predictions of "immense spouters," in case a suitable test should be made under their direction. At the same time that they increased the general clamor for some costly test, they increased the general distrust of all geologists and geological evidence by

saying that the geologists know nothing about where gas can be found, quoting the experience at Findlay, O., as evidence of it, and affirming that gas issues everywhere when it is properly sought for.

3. In addition to these facts are some published facts of observation, found in the geological reports of the state. In volume one of the final report, page 384, are given the particulars of an exploration for coal at Freeborn, in Freeborn county, in which gas was met with in the process of sinking a shaft. On page 388 it is stated that some of the common wells in the western part of Freeborn county are injuriously affected by the prevalence of carbureted hydrogen gas. On page 488 is a record of carbonic acid gas in a well in Manyaska, in Martin county. On page 552 Thomas Kennedy's well is described. In it are found the remains of wood, such as logs, bark and leaves of trees, and a dangerous gas gathers rendering the water poor and unfit for use. On page 629 is mentioned the well of J. P. Edwards, situated in Prior, Big Stone county, and that of Samuel Varco, both of which met with gas. The statement is made that at the depth of about 100 feet wells in that neighborhood generally encounter gas, with water, coming from a dark-colored sand.

4. Other facts of a similar nature were in the possession of the survey, derived from various counties, some from Stearns, some from Nicollet and others from Hennepin and from Blue Earth, though still unpublished.

THE INTERPRETATION THAT HAD BEEN MADE OF THESE FACTS.

By the state geologist all these signs of gas had been ascribed either to vegetable deposits in the drift or to the Cretaceous. It is now better known than before the recent great developments in Ohio and other central states which have led geologists and others to scrutinize closely all sources of illuminating gas, that a limited amount of gas, undistinguishable from that which issues from the bed-rocks, is found sometimes, in the drift. This seems to be due to the decay of vegetation embraced between the deposits of the two ice-epochs, generally; but may be produced by the burial of vegetation under the operation of much more limited agencies, such as by the flood-stage of rivers or the high tide waters along the sinking sea-coast, or the lacustrine spreading of waters in low grounds toward the close of the last glacial epoch.

As to the Cretaceous origin of some of this gas, there was abundant reason to suspect that the lignites and lignitic beds of that age might be the source of this gas in those instances where the beds of the Cretaceous were known to exist in the neighborhood. In the Cretaceous all the conditions necessary for the production and retention in reservoirs below the surface of considerable quantities of illuminating gas are found to coexist not only in Minnesota but throughout a large extent of territory in Dakota. The lowermost layers of the Dakota group in Minnesota seem to consist, in some places, of lignitic clays and lignite beds, though in others the bottom of this group is sandstones and conglomeritic sandstones. Overlying this is an impervious sheet of clays and carbonaceous shales, dark, plastic, often finely laminated, belonging to the Benton group. These beds would not only themselves be likely to be a source of illuminating gas, but would serve as a tight canopy to retain any that might be generated by the vegetable remains in the underlying Dakota group.

From the greater portion of the state where these signs of gas were known the Trenton formation is wanting, and from the whole of the state the rocks of the Carboniferous age are wanting. In the light of the great developments in Ohio and Indiana of gas from the Trenton. attention was at once attracted to the Trenton formation in Minnesota, and the known and supposed extension of those strata under the surface of the state was closely outlined and carefully considered. The conclusion was reached that the Trenton limestone might be the source of gas in Minnesota, and that in those areas where it was reasonably supposed to lie below the surface, as in Freeborn and Mower counties, at the depth of several hundred feet, it might embrace the natural conditions which it manifests where it is gas-bearing in other places, and it might have a sufficiently close covering in the form of the green and blue shales of the Cambrian [Cincinnati group] to retain such gas within its own porous substance. This consideration was rendered the more reasonable, and more in keeping with the conditions delineated by Prof. E. Orton concerning the Trenton as a gas-bearing rock, by the known fact that the upper part of the Trenton (the Galena) is, in southern Minnesota, and in northeastern Iowa, a porous magnesian limestone. Hence it seemed possible that all the gas known to escape from the surface of the ground, or from wells in that area, might emanate primarily from the Trenton, though

known only as coming immediately from the Cretaceous or from the drift. It was also remembered that at Findlay the real source of the gas which escapes at the surface through crevices in the Niagara limestone and in the drift, is in the Trenton limestone at a depth of 1,648 feet below the surface.

FACTS THAT HAVE TRANSPIRED SINCE THE PASSAGE OF THE LAW, RELATIVE TO THE EXISTENCE OF NATURAL GAS IN MINNESOTA.

When the law was passed, and for some time before, parties had been engaged in drilling test wells at several places. One was at Faribault, and from this well was reported with particularity, and positiveness, the discovery of coal, marble, and the "conglomerate rock," in which last were said to be evidences of gas. Fair samples of anthracite coal were shown to all who desired to examine it, which were averred to have come from the bottom of this well. Other wells were being sunk at St. Paul, and in South St. Paul, and another at the State Fair Grounds, intermediate between St. Paul and Minneapolis. Gas was reported to have been found issuing from several places at St. Paul and particularly from the St. Peter sandstone near Fort Snelling, on the east side of the Mississippi. Considerable quantities of inflammable gas were exhibited and burned in public places by parties interested in some of these wells, said to have been obtained within a few miles of the Capitol building. At Hastings gas was discovered, as claimed, along the bluffs of the river, and a company was to be organized to bring it into economic recognition and use. At Freeborn, in Freeborn county, the old gas-supply was re-examined. Three drilled wells were sunk to the depth at which gas was found, and gas-pipes were inserted in them with gas-burners at the upper ends. From these the gas was seen to issue, and on applying a lighted match would burn with considerable heat and light. At Duluth a company began to drill for gas, another began at Stillwater and still another at Moorhead and another at Mankato. One was begun also in North St. Paul. The fever spread throughout the state. It is probable that but few counties can be named in which there has not been more or less agitation and some proposals by capitalists to bore for gas—the last being at Minneapolis, where it is reported a gentleman who is familiar with the Pennsylvania gas region, is sure he can see the "first and sec-

end sandstones," and the correct geological relations that indicate the surety of getting a large flow if a proper test should be made.

WHAT HAS BEEN DONE BY THE SURVEY TO DISCOVER THE POSSIBLE GAS-RESERVOIRS IN MINNESOTA.

Although the terms of the law making it the duty of the state geologist to undertake a search for economic products are very broad, it was plain that the first expenditure should be for the discovery of gas. There are other economic interests that justly claimed a representation in any such public expenditure, and specially the iron resources of the state, both so far as known and developed, and particularly the unexplored iron regions of northeastern Minnesota which may be said simply to have been discovered, not explored.

Accordingly negotiations were entered into with the St. Paul Heat and Power Company, of St. Paul, who had been sinking a deep well near the State Fair Grounds between Minneapolis and St. Paul, and at other points, in search for gas, for the purchase of one of their deep-well outfits, including steam engine and all appliances and tubing for a deep well two thousand feet deep, six inches in diameter. This also included the derrick which had been erected on the grounds. This was transported to Freeborn county and was put to use in drilling a six-inch well at Freeborn, in that county, in order to ascertain, if possible, the origin of the natural gas that escapes there and is burned at the upper ends of the pipes. The machinery is still there, and is engaged in the same undertaking, under the charge, and at the cost of the Minnesota Natural Gas, Oil and Fuel Company, at Albert Lea.

The operations at Freeborn.

It will be best to rehearse the facts which led to the selection of this point in the state at which to make the first trial for natural gas.

In the third annual report of the survey (for 1874) the first report on Freeborn county was given, and includes the following account of

"*Explorations for coal.*

"In common with many other places in southern Minnesota, Freeborn township, in the northwestern corner of this county, has furnished, from the drift, pieces of Cretaceous lignite that resemble coal. Those have in a number of instances incited ardent expectations of coal, and led to the outlay of money in explorations. Such pieces are taken out in digging wells. The opinion seems to grow, in a community where such fragments are found, that coal of the Carboniferous age exists in the rocks below. In sinking a drill for an artesian well, at Freeborn village, very general attention was directed to the reported occurrence of this coal in a regular bed in connection with a 'slate rock.' This locality was carefully examined, and all the information was gathered, bearing on the subject, that could be found. The record of the first well drilled is given below as reported by the gentleman who did the work:

1.	Soil and subsoil, clay	15 feet.
2.	Blue clay	35 feet.
3.	"Conglomerated rock" (hard to drill)	2 inches.
4.	Sand, with water	5 feet.
5.	Fine clay, tough, hard to drill, with gravel and limestone pebbles	60 feet.
6.	Sand, with water	4 inches.
7.	"Slate rock" } probably Cretaceous.	7 feet.
8.	"Coal" } probably Cretaceous.	5 ft. 4 in.
	Total depth	122 feet.

"This indication of coal induced the drilling of another well, situated 100 feet distant, toward the N. E. In this the record was as follows, given by the same authority:

1.	Soil and subsoil, clay	15 feet.
2.	Blue clay	33 feet.
3.	"Conglomerated rock"	2 inches.
4.	Sand with water and pieces of coal	12 inches.
	Total depth	60 ft. 2 in."

Further exploration was made in the sinking of a shaft in the same vicinity, but at the depth of 35 feet the work was so impeded by the influx of water, and the workmen being without adequate knowledge and means for removing it, it had to be abandoned.

At still another point, about three-fourths of a mile north of this place, a shaft was sunk to the depth of 57 feet, the strata having been tested first by a drill-hole to that depth. In this drill-hole gas was first met with in noticeable quantity. It rose above the top of the pipe, and being ignited it flamed up eight or ten feet with a roaring sound. The shaft was so near the drill-hole that it drew off the gas gradually, as supposed, allowing the intermixture of so much air that rapid burning was prevented. The exploration here being given up it was resumed at the former place, where another shaft was begun. But water

entered the shaft so copiously that the work had to stop at 106 feet. The water here was impregnated with the same gas as that which rose in the drill at three-fourths of a mile further north. Such water was also found in the well at the hotel at Freeborn. A test was made with sugar of lead for sulphureted hydrogen, but as it failed the gas was presumed to be carbureted hydrogen.

Again in 1880 this search for coal was resumed by Mr. E. B. Clark, who caused a shaft to be sunk 144 feet,* with the following result:

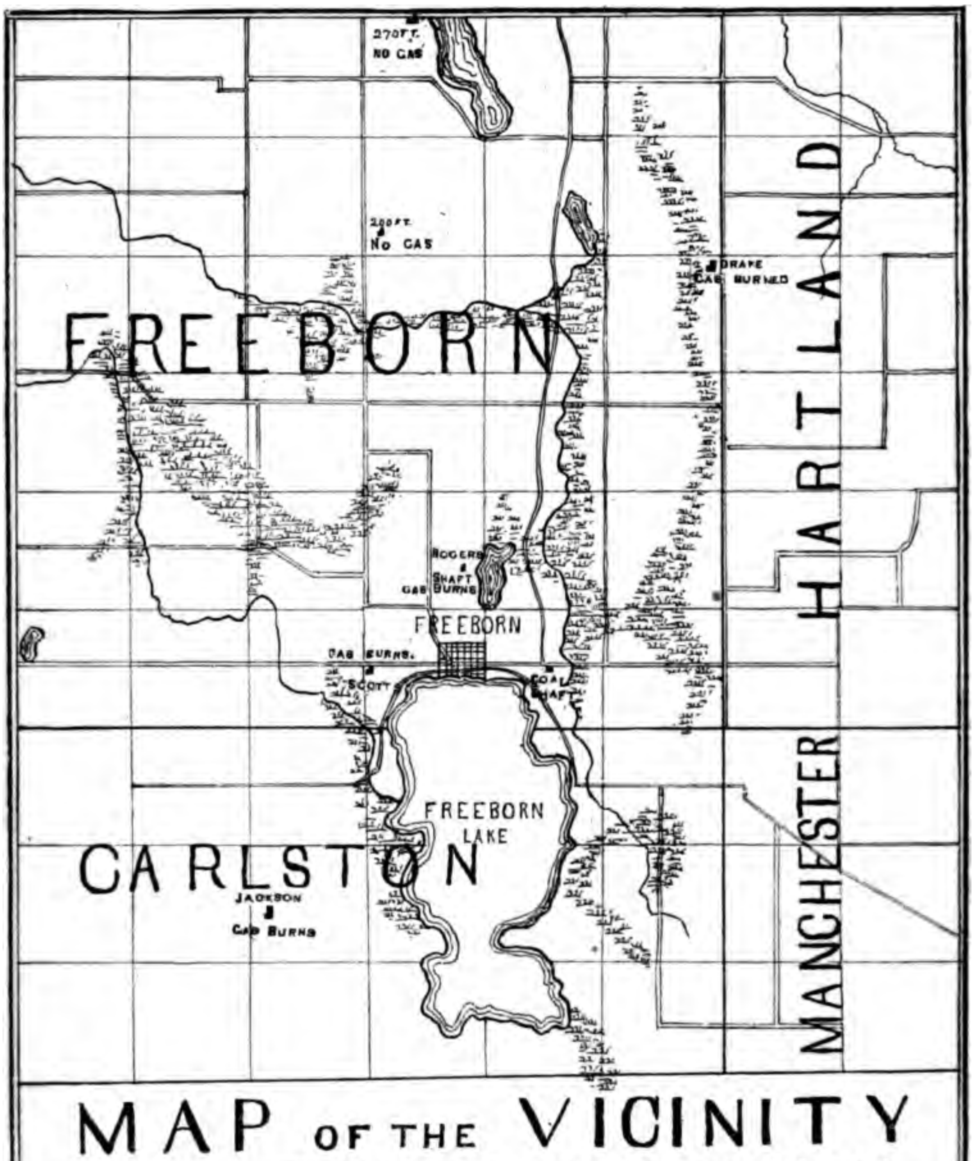
Soil	2 feet.
Yellow till	14 feet.
Softer blue till	29 feet.
Sand	1 foot.
Gray till, harder than the yellow till	47 feet.
Sand	1 foot.
Gray till	2 feet.
Quicksand	44 feet.
Total depth reported	130 feet.

At the depth of 124 feet from the surface Mr. Clark reported a stratum of slate two inches thick, "underlain by six inches of soil." The bottom of this exploration was said to have been *drilled* four feet in "slate." By the term slate in all these wells the workmen designate the slaty gray shale which appears in many places in the drift in Minnesota and is derived from the Cretaceous. When it is more than usually abundant it indicates the near proximity of the beds from which it is derived, and in some instances it has been found on excavation, or is in outcrop in the neighborhood along some stream or ravine. The county reports that have been published contain numerous proofs of the nature and origin of this "slate."

A visit was made to the locality before work was begun, and further information was obtained respecting the extent of these evidences of gas. By the aid of some of the citizens of Albert Lea, who had become informed of the former indications and their significance, several new trials had been made, and the flow of gas had been restored and had been conducted to burners which were regulated by thumb-stops.

The small map accompanying shows a section of that part of Freeborn county which embraces the area of natural burning gas. On returning from this visit the following letter was written:

*Vol. 1, final report, p. 385.



MAP OF THE VICINITY OF FREEBORN MINN.

To Show the Region of Natural Gas

By N. H. Winchell.

MINNEAPOLIS, MINN., June, 16, 1888.

To the Minnesota Gas, Oil and Fuel Company, Albert Lea, Minn.,

GENTLEMEN: At your request I give herewith a brief statement of the results of the examination I made of the gas wells at Freeborn last week.

There was a party of fifteen or more, and they all witnessed the exhibition of gas-burning from the tops of two inch pipes sunk into the earth about seventy-five feet. That there could be no deception as to the genuineness of this, and the origin of the gas as claimed, the sand pump was sunk into each one and gravel and clay were brought from the bottom. The pumping was also intended to relieve the gas from obstructions caused by water and gravel which get into the pipe and choke the flow of gas. Four such wells are in existence in the immediate vicinity of Freeborn, and afford gas intermittently, the stoppage being caused probably, as represented, by obstructions that now interfere with the current of gas, and choke up the bottom of the pipe. I am credibly informed also that indications of gas have been met with in numerous other instances in the sinking of wells in the neighborhood of Freeborn, and I know, of my own observation, that, now nearly fifteen years ago, when I first surveyed Freeborn county, such exhibition of gas was witnessed in the sinking of a shaft for explorations for "coal," and that it permeated the water of some wells and rendered the water unfit for general use.

The current of gas coming from one of these wells burned with considerable roaring, when allowed to escape in full force, issuing from a series of gas-jets arranged about a central disk, and, when regulated by the stop-cock, it becomes luminous, and burned with the regularity of any gas-supply.

The country round about is an open, ordinary prairie, like that seen in much of the southern and western part of the state, there being no rock exposure in any direction for many miles round. The evenly spread drift has an unknown thickness, and the surface drainage, while finally reaching the streams that flow into the Minnesota river, yet is so sluggish that numerous marshes are caused on the level prairie, and some shallow lakes of considerable size. These wells are on the west side of the morainic tract which passes through the county and which constitutes actually the highest water-divide, but they are not much lower than that divide.

In the absence of reliable data for determining the character

and age of the underlying rock at Freeborn, I can only give you hypothetical explanations of the source of this gas, and must defer till some new facts are ascertained, all positive statements. The general geology of that part of the state will permit the existence of either one or two of those formations that supply gas, at Freeborn, viz.: the Cretaceous, or the Trenton. The Cretaceous is known in some places in the western states and territories to contain not only lignite, and possibly to furnish petroleum, but also to give origin to natural gas, and it has been my opinion that the gas at Freeborn issued primarily from the rocks of that age. The "coal" that was sought by shafting at Freeborn in 1873 and 1874 was Cretaceous lignite, and the reports that were given me of the materials passed through, while evidently so described and modified as to fit the true Carboniferous rocks of Iowa, yet were, so far as I could see, indicative of the Cretaceous only. The deepest was about 128 feet, and at the bottom was said to be "coal."

I think the Trenton formation may exist below Freeborn. Indeed it is very likely to be found, in case of drilling a deep well at a depth not to exceed one thousand feet, and possibly not 500 feet. This formation is well known in Indiana, in Illinois and Ohio as the source of great quantities of natural gas, and it may be the source of that at Freeborn. Even if gas issue now from the Cretaceous, it may come primarily from the Trenton. At Findlay, Ohio, it rose from the Trenton through several hundred feet of strata, and at the surface escaped for thirty years from the Niagara limestone. It was only a deep well that penetrated the Trenton that revealed its real origin. So here, in case of drilling at Freeborn, the drill ought not to cease till the Trenton be reached, even if gas in considerable amount should issue before reaching it.

In conclusion: I am satisfied, both from the facts above stated, and from the analysis made by Prof. Dodge,* that the gas that issues at Freeborn is natural rock gas; that the geology of that part of the state, so far as it is known, is favorable for the existence of the Cretaceous and the Trenton formations in that part of Freeborn county; that either of these may be the source of

* Two samples were submitted to Prof. Dodge. These were obtained and transported under unfavorable conditions, and there is no doubt that the gas became mixed with common air before they reached him. He reported in one sample common air 47.37 per cent, and marsh gas or light carbureted hydrogen, 51.98 per cent. In the other sample he reported common air 24.59 per cent, and marsh gas or light carbureted hydrogen, 74.58 per cent. In each case there was less than one per cent of carbonic acid gas.

this gas; that the imperfect developments which you have prosecuted are ample to show the probability of a great gas reservoir that can be reached by a deep drill; and that all the indications warrant me in saying that you should by all means prosecute the investigation to its final result, and that too as soon and as rapidly as is consistent with due economy.

In view of the importance of this investigation to the State at large, I shall take pleasure in allowing the use of the deep well machinery belonging to the State, in such a test; and under the law of the appropriation made by the last Legislature, will allow such further aid as I consistently can to have the exploration made thorough and complete.

Respectfully,
N. H. WINCHELL,
State Geologist.

Accordingly the drilling machinery was removed from St. Paul to Freeborn and a well was begun which has reached the depth of 535 feet, giving the following record. The drillings are deposited at the university.

The record of the Freeborn gas well.

		Depth.
1.	Yellowish-blue pebbly clay	20 feet.
2.	Slightly darker pebbly clay	30 feet.
3.	The same	40 feet.
4.	The same	50 feet.
5.	The same	60 feet.
6.	The same	70 feet.
7.	Gravel and sand, bearing gas	74 feet.
8.	Same as No. 3, pebbly clay	80 feet.
9.	Same as No. 3, pebbly clay	90 feet.
10.	Same as No. 3, pebbly clay	100 feet.
11.	Same as No. 3, pebbly clay	110 feet.
12.	Same as No. 3, pebbly clay	120 feet.
13.	Drift gravel and sand, with fragments of lignite	130 feet.
14.	Drift gravel and sand, with many fragments of gray limestone	140 feet.
15.	Fine quicksand	145 feet.
16.	Magnesian buff porous limestone, resembling Galena, mixed with drift pebbles	150 feet.
17.	Magnesian limestone drillings, but mingled with some siliceous drift pebbles derived evidently from above. The rock fragments are small and apparently also argillaceous	160 feet.
18.	Gray limestone, compact, apparently Trenton, also mingled with some drift	190 feet.

(No samples at 170 and 180 feet.)

19. Same as the last, but with slight signs of drift.......... 200 feet.
20. Same as the last, but containing broken pebbles of drift material, evidently from above.......... 210 feet.
21. Coarse drift pebbles, some of the larger ones of limestone like No. 16. The pebbles are of greenstone, granite, and quartzyte.......... 220 feet.
22. Dolomitic, but mixed with grains of pure quartz, very fine-grained, buffish-gray, having a rapid effervescence.......... 230 feet.
23. The same, but the limestone is nearly white, and compact, some chert fragments are visible.......... 240 feet.
24. Gray aluminous limestone.......... 250 feet.
25. •Gray limestone.......... 260 feet.
26. Gray limestone.......... 270 feet.
27. Gray limestone.......... 280 feet.
28. Gray limestone.......... 290 feet.
29. Gray limestone.......... 300 feet.
30. Gray limestone, finely crystalline.......... 310 feet.
31. Gray limestone, with siliceous grains.......... 320 feet.
32. Gray limestone.......... 330 feet.
33. Gray limestone.......... 340 feet.
34. Gray limestone.......... 350 feet.
35. Gray shale, with quick effervescence.......... 360 feet.
36. Gray limestone.......... 370 feet.
37. Bluish gray shale; slight effervescence.......... 380 feet.
38. Bluish gray shale; pebbly.......... 390 feet.
39. Fine bluish shale.......... 400 feet.
40. Coarser shale, containing pebbles of limestone and various crystalline rocks.......... 410 feet.
41. Fine homogeneous gray shale.......... 420 feet.
42. A mixture of blue and gray shale and limestone containing pebbles and Trenton fossils. Here was said to be a good show of oil; but it was only temporary, and no trace of it could be found at a subsequent visit.......... 430 feet.
43. Same as the last, the oil signs ceased.......... 440 feet.
44. Fine blue-gray shale, containing grains of silica.......... 450 feet.
45. Blue shale.......... 460 feet.
46. White sandstone, evidently the St. Peter sandstone. Here a green oily appearance is reported to have been conspicuous for a time but was soon lost.......... 470 feet.
47. White sandstone.......... 480 feet.
48. White sandstone.......... 490 feet.
49. White sandstone.......... 500 feet.
50. Green shale, dark, 5 feet thick. The well is cased to this green shale — i. e., the inner casing, 5⅝ inches in diameter.......... 510 feet.
51. White sandstone.......... 515 feet.
52. White, fine sand. The superintendent here declares that he is sure that a flow of gas was met, and that it is necessary to shut off the water to develop it.......... 535 feet.

Subsequent to the above the drillings were not so frequently preserved. Mr. H. G. Day sent samples which afforded the following further record.

53. At a depth of 710 feet samples show a fine-grained magnesian limestone. The letter (Jan. 7, '89) accompanying this states that "the drill is now down 700 feet, and while it is not yet below what you designate St. Peter sandstone, the formation has materially changed in the last 50 feet. The rock at intervals of 5 to 15 feet is intensely hard, the thickness of the hard rock being at times an inch or two, and again several feet. Under each hard substance, is a cavity or very soft porus rock or sand, and when the drill went through into these cavities, in each case very strong coal oil or gas odor came to the surface. The sand bucket was impregnated with the odor so strongly that it filled the derrick room." If this change in the rock had been going on for 50 feet, the bottom of the St. Peter was at a depth of 650 feet, or 180 feet below the point above recorded at which it was first recognized. Sixty feet of the Shakopee limestone; at .... 710 feet.

54. The next sample sent in is a white saccharoidal, rounded, sandstone, with the record: "21 feet of this at a depth of 840 feet." There is hence an interval of 109 feet unknown......... 840 feet.

55. Slowly effervescing magnesian limestone, with the note: "Ten feet of this at a depth of 880 feet, underlying and overlying sandstone."................... 880 feet.

56. Mottled green and reddish shale, with the note: "A thin stratum of the green shale overlying 18 feet of red shale. Green shale struck at 900 feet." This green shale is undoubtedly within the St. Lawrence horizon (the "Mendota beds" of Wisconsin), and that allows the interval from 650 feet to 900 feet for Shakopee limestone, the Richmond sandstone. the main body of the Lower Magnesian and the Jordan sandstone. This interval, amounting to 250 feet, can not be subdivided accurately because of the lack of record. This shale, with varying amounts of magnesian limestone, continues to the bottom of the well, at 950 feet .... 900 feet.

57. Drillings made up of green shale and magnesian limestone, mostly the latter. Taken at depth of.................... 920 feet.

58. Drillings mainly of fine-grained, nearly white, magnesian limestone, but evidently also siliceous, but with some fragments of purplish shale. The accompanying note is: "About 20 feet of this." Taken at.................... 930 feet.

59. Much like the last, but more siliceous; effervesces generally, but leaves a large insoluble residue. This is probably from some of the layers of the St. Lawrence, and can not be further defined. Has some greenish shale.................... 950 feet.

By a condensation of the record the following appears to be the geological position of this well:

1.	Drift	150 feet.
2.	Galena limestone	10 feet.
3.	Trenton limestone and shales	310 feet.
4.	St. Peter sandstone	180 feet.
5.	Lower Magnesian (with its parts, Shakopee, Richmond and main body of limestone), and Jordan sandstone	250 feet.
6.	In the St. Lawrence limestone (with the accompanying shales): pierced	50 feet.
	Total	950 feet.

Under date of Dec. 5, the investigation was still going on. Mr. H. G. Day, who has been active in promoting this enterprise, says: "We found oil of the pea-green color (petroleum) in small quantities in the Trenton. At a depth of 534 feet Mr. Bowland (the superintendent) claims he found a vein of gas of about the character of that in the exhibition wells, but water was coexistent and it could not well be cased off; so he bored further, and at a depth of 565 feet he claims to have found the strongest vein of gas yet encountered there. It certainly gave the gas odor, and filled the atmosphere with its fumes for several rods about. Every bucket that came up brought the odor, but as the well was nearly full of water, it was impossible to fully test it. We have been at work lately trying to case off the water from this vein, but have so far failed, although we have cased down with seed-bags and closed the hole tight around the casing at the bottom three times. The water vein was lower and we could not clear the well of water. While waiting for some elevators to lift and lower the casing we are now boring deeper. If we find nothing important before the elevators come we shall then make further efforts to case off the water just above the lower gas vein, and we intend to persevere in that purpose. If we fail, or if the gas does not show itself, as all believe it will do, we are determined to go deeper, perhaps 2,000 or 3,000 feet, and we very much desire to use your machinery therefor. Our 'backers' want to make a thorough investigation, and seem willing to stand the expense."

Mr. Day also says, under date of Dec. 13, '88; "We have been using every effort during the past two or three weeks to shut off the water in our well at the gas indications, 465 feet, and have had the help of three experts, men as capable as any to be had.

But it is impossible, we at last found, as the water and gas indications are coexistent. These men agree that there are almost certain evidences of gas, such as would be considered sure in the gas regions of the east. We are boring deeper, and want to go down 2,000 feet if necessary. We want to make the test thorough, and all concerned will not be satisfied otherwise."

This being the situation at Freeborn at the present time, the search not being concluded, it will be next in order to rehearse the facts connected with some other wells in the same county.

Other wells in Freeborn county.

In the immediate vicinity of Freeborn several common wells have been found to develop, at the depth of something less than 100 feet, the same signs of burning gas as Mr. Scott's near the village. Of these the farthest northeast is in the northeast quarter of sec. 13, Freeborn, and the farthest southwest is in the western part of sec. 9, Carlston, separated from each other about seven miles. Several others intermediate between these extremes are so situated, including that at Scott's where the above test was made, that the direction of greatest evidence of gas seems to run in a narrow belt extending about N. E. and S. W. In general, about Freeborn, common wells pass through first about 70 feet of blue till, then a dark clay about 3 feet, sand about six inches, giving the gas flow, and then blue clay ("till") extending down to the rock, which is struck at about 150 feet. The rock is struck at 150 feet at Hartland. At a mile and a half south from Hartland, four miles east of Freeborn a well penetrated to a depth of 226 feet, which included 40 feet in rock, with no sign of gas. The rock was found to be a white magnesian limestone like that in the deep well at Albert Lea. Toward the west and northwest, in Freeborn county, from the point at which the above test was made for gas nothing is known as to the existence of gas at any depth, as no wells sufficiently deep have been dug.

In Bath township, Mr. Michael Whalan, N. W. ¼, S. W. ¼ sec. 33, T. 104, 21, and Mr. Hans Nelson in N. E. ¼ N. E. ¼ sec. 4, T. 103, 21, Bancroft, found, at the depth of 190 feet, a gray sand of medium grain in the drillings from which were found fragments of charcoal and black, lignitic cellular woody material which resembles that found in the lignitic beds of the Cretaceous

at Redwood Falls.* The record of these wells has not been preserved. But, besides the above, the drillings from the depth of 248 feet have been furnished by Mr. H. G. Day. The latter consist entirely of fine white sand which seems to be the downward extension of that at 190 feet, as it embraces sparingly fine fragments of the same vegetable matter. Mr. Whalan's well was 300 feet deep, and Mr. Nelson's 260 feet.

The deep well at Albert Lea. The drillings from this well, which is 300 feet deep, were furnished by mayor A. C. Wedge. The well was made by Mr. Swanson in the summer of 1885. This well is situated in the high level near the business portion of the city, and the water stands at 22 feet below the surface. About 60 rods from this well Mr. William Morin sank another, beginning at a lower level, in the bed of what was once Spring lake, and penetrated to the depth of 204 feet. Flowing water in this well was obtained at 120 feet, but the well was continued deeper with a hope of getting a stronger flow. The discharge is about 400 barrels per day, of good quality and a temperature of 50 degrees, Fah. The drillings of this well have not been examined, but it is the opinion of mayor Wedge that the strata struck proved to be about the same as those given below as far as the drill penetrated. The water is apparently of the same quality. The iron films from the depth of 165 feet were derived from a bucket which became fast in the well and was drilled out.

1. Mus. Reg. No. 6191. Drift gravel, largely limestone, from the depth of........ 80 feet
2. " " " 6192. Drift sand and gravel, from........ 95 feet
3. " " " 6193. Drift sand, mainly quartz, from........ 105 feet
4. " " " 6194. Drift gravel and sand, from........ 112 feet
5. " " " 6195. Drift sand, from........ 113 feet
6. " " " 6196. Drift sand, with magnesian limestone, from........ 114 feet
7. " " " 6197 and 6198, Magnesian limestone and sand, from........ 115 feet
8. " " " 6199. Drift sand, with some limestone, from........ 130 feet
9. " " " 6200. Magnesian Limestoue, with a few grains of drift sand, from... 143 feet
10. " " " 6201. Light-gray shale, slightly effervescing........ 155 feet
11. " " " 6202. " " " "........ 160 feet
12. " " " 6203. Battered films of metallic iron, somewhat rusted, from........ 165 feet
13. " " " 6204. Gray shale, sandy, effervescing, with some films of iron, from.. 172 feet
14. " " " 6205. Gray shale, from........ 210 feet
15. " " " 6206. Gray shale, from........ 213 feet
16. " " " 6207. Calcareous shale, nearly white, from........ 220 feet
17. " " " 6208. Campact, light-colored limestone, mixed with some drift-sand from above, or some arenaceous stratum, from........ 230 feet
18. Mus. Reg. No. 6209. Drillings have a mixed composition; though mainly of magnesian limestone, yet of different grain and color; also containing considerable sand, and some chert and fine crystals of silica referable to geodes in the rock; one large fragment is distintly arenaceous, from........ 234 feet
19. Mus. Reg. No. 6210. Mainly white quartz sand, rounded and also angular; the rest is magnesian limestone, readily effervescing; both are in fine grains and fragments, from........ 206 feet

* Vol. I, final report, p. 578-9.

20. Mus. Reg. No. 6211. Same as the last, from .... 237 feet
21. " " " 6212. Same as last, from .... 240 feet
22. " " " 6213. Mainly a homogeneous, buff, magnesian limestone, with some quartz sand, from .... 241 feet
23. Mus. Reg. No. 6214. The drillings consist, mainly of the same, light-buff magnesian limestone, but contain also numerous pieces of a dark earthy shale, not inflammable nor combustible, from .... 243 feet
24. Mus. Reg. No. 6215. Reddish-buff magnesian limestone, with some fragments of opaque white silica and some rounded sand, from .... 248 feet
25. Mus. Reg. No. 6216. Same as the last, from .... 250 feet
26. " " " 6217. The same without silica and sand, from .... 254 feet
27. " " " 6218. Reddish-buff, compact, magnesian limestone, from .... 258 feet
28. " " " 6219. The same, from .... 260 feet
29. " " " 6220. Reddish-buff, compact, magnesian limestone, mottled with gray, from .... 265 feet
30. Mus Reg. No. 6221. The same, without gray mottlings, but with some chert and some sand, from .... 270 feet
31. Mus. Reg. No. 6222. Light-gray to buff, crystalline magnesian limestone, with rare beads from crinoid filaments, from .... 275 feet
32. Mus. Reg. No. 6223. Buff magnesian limestone, from .... 285 feet
33. " " " 6224. Light-buff magnesian limestone, some of the drillings being unwashed, and then, dried, resembling a light-gray shale, from .... 295 feet
35. Mus. Reg. No. 6225. Vesicular, buff, magnesian-limestone, resembling the upper part of the Niagara limestone, from .... 300 feet

There is but little to serve as a guide in assigning these limestone strata to their geological horizon. There is, in the Albert Lea well, a thickness of about 186 feet of limestone which does not vary very much lithologically, extending from 114 feet to 300 feet. It is shaly in some places, and also arenaceous. These characters would not preclude the Galena limestone, which is thought to be the most probable rock in that geographical area. If, however, the Devonian limestones extend as far north as Albert Lea, these beds could all be assigned to that age, as far as their lithology is concerned, except Nos. 33 and 34, which have a greater resemblance to the Niagara. This would bring the Devonian upon the upper Silurian, as supposed in the deep well at Austin.* The shale extending from 155 to 220 feet, a thickness of 65 feet, would, in that case, represent the Austin rock, and the mixed and arenaceous beds extending from 220 feet to 240 feet would parallelize with the conglomerate of the Austin well. There would be then 45 feet of magnesian limestone in the Albert Lea well, below the conglomerate horizon before the lithology of the Niagara is recognizable. This would fall into the upper part of No. 8 of the Austin well.

More recently several other wells have been drilled at Albert Lea, and some have obtained an artesian flow of water. Incomplete records of some of these wells have been obtained.

The "Greene-Dommick company" well is three blocks west

*The record of the Austin deep well is given in the 14th annual report, p. 16.

of the city park. It had 92 ft. 4 in. to the rock, the drift consisting of sand followed by 50 feet of blue clay, four feet of gravel, and a hardpan, which last lay on the rock. The first rock was a buff magnesian limestone of fine grain, effervescing freely, resembling the Onondaga portion of the Devonian limestones as described in Ohio, and also in the report on Fillmore county.* This had a thickness of 20 feet. This was followed by a shale three feet in thickness, and the shale by 40 feet of bluish, very fine-grained sandrock resembling the Austin rock, so-called, but effervescing freely, and disintegrating, leaving an impalpable residue. Below this the workmen reported a "crevice" 15 inches in perpendicular thickness, from which were shown some pebbles and fragments of white granular quartzyte and one of a dark gray, arenaceous quartzyte. Under this was a porous, nearly white, fossiliferous limestone which is easily referable to the Niagara such as that described in the southern part of Fillmore county ** and on the Mississippi river further southeast. This extends, with some variation to compacter texture, and the intermixture of some rounded grains of white quartz, to at least the thickness of 20 feet below the crevice, at which point the record is broken, and nothing further is known till at the depth of 212 feet when the drillings show a compact saccharoidal limestone which had been pierced six inches. It may fairly be presumed, since no drillings were shown, that no change worthy of note took place in this unknown interval, and that the Niagara extended downward to the last — which itself also seems to belong to the Niagara.

At Albert Lea a mucky deposit is found in some wells at about thirty-eight or forty feet below the surface. This is associated with quicksand, and contains leaves and sticks. It renders useless some of the common wells. Other wells in the vicinity of Albert Lea yield a gas which on being examined by Prof. Dodge was found to be carbonic dioxide. When this was first discovered it was supposed to be burning gas of the same quality as that at Freeborn, but it would not ignite.

DEEP WELLS IN OTHER PARTS OF THE STATE.

The exploration at Mankato. Prompted by the prevalent idea that gas must exist in many unknown reservoirs in the crust of the earth, capriciously formed and distributed in a manner

* Final report, Vol. I, p. 303.
** Final report, Vol. I, p. 302.

wholly unknown and inexplicable by geology, some parties at Mankato organized a company and sought the services of the diviner's-rod. A gentleman by the name of Booker was paid $250 for "locating" the gas veins at Mankato. This "witch," whose services are well known in Ohio where he has been extensively advertised by his bombastic circulars, passed over the ground, and, as reported, was taken with jerks and shakings so violently in certain places over which he passed that he could not endure the current. He was obliged to stand on one foot, placing the other against his knee to break the electric flow. He predicted that a gas flow equal to that at Van Wert, Ohio, would be obtained by drilling at the point he designated, which was near Minneopa falls, about where the company desired to drill.

Here a well was drilled to the depth of 1,000 feet, giving artesian water, and reputed to have brine at the bottom, with the following imperfect record, which is ambiguous in some of its parts:

Record of the deep well at Minneopa falls, near Mankato.

1. "Loose soil, sand and gravel," about .... 100 feet.
2. "Blue slate," probably a shale of the "Mendota" horizon, about .... 10 feet.
3. "White sandstone," about .... 35 feet.
4. "Red stone, clay-like," about .... 20 feet.
5. "Bluish slate, white when dry," about .... 100 feet.
6. "Pink sand," about .... 10 feet.
7. "More white sand," about .... 100 feet.

Then comes the quartzyte, which was struck at 585 feet.

[No samples of these strata above the quartzyte were seen by the writer, but the description is such as was given by the gentleman (Fox) who was last in charge of the well. This record seems defective, since among the drillings preserved, of which samples are deposited at the University, is a magnesian limestone at the depth of 117 feet, and other samples as detailed below.]

8. Magnesian limestone, some of it being pinkish and easily effervescing, and other parts being specked with greensand, like that seen at the quarries at Judson,* a few miles northwest from this place. Said to be the first rock struck — 117 feet below the surface. The pipe is driven down to this. Thickness .... unknown.
9. Whatever the succession of parts above, there is a substantial accord in all the evidence that a red quartzyte and pebbly conglomerate was struck at 585 feet. Prof. Bechdolt is of the

*Final report, Vol. I, p. 425.

opinion that the whole of this was conglomeritic. This is the New Ulm rock, the "Baraboo quartzyte," the Huronian quartzyte of Wisconsin, the Wauswaugoning quartzyte of Pigeon point, the Pewabic quartzyte of the Giants' range, the Pokegama quartzyte of the upper Mississippi, the Thessalon quartzyte of the original Huronian in Canada, the Potsdam quartzyte of the Adirondack region, the "granular quartz" of the Green mountains, and the "red sandrock" of the Champlain valley, and probably the Braintree quartzyte of Massachusetts. There is a remarkably uniform lithology and constancy of general stratigraphic relations that attend this great quartzyte from Minnesota to New England. In New England it has given fossils that fix it in the primodial zone, and the same have been found in it at Pipestone in Minnesota, about .... 200 feet.

10. Below this quartzyte and conglomerate was found a grayish hard rock which in the drillings is fine and nearly black. These drillings contain magnetite in considerable amount, which when examined for titanium show the rock is not titanic, and hence that the stratum is probably not the equivalent of the gabbro of northeastern Minnesota, as it was first suspected of being. It is on the other hand likely some part of the dark slates of the Animike which often contain non-titanic magnetite.* Under the microscope this proves to be a highly quartzose fragmental rock, about .... 60 feet.

11. Associated intimately with this, and not distinguished from it by the drillers, is a light reddish soft rock, the drillings of both sorts appearing in the same collection, and both being said to have been "first below the quartzyte." This reddish rock soils the fingers, but some of it is harder and will not crush easily. Parts of it are kaolinic, even white, and it also contains some crystals of calcite which show rapid effervescence. A few of the grains put into hydrochloric acid soon form a jelly, showing the probable presence of some zeolitic mineral, perhaps laumontite. The general aspect of this soft red rock, which also contains some fragments of hard red felsyte, is the same as that of the "ash-bed conglomerates," and laumontitic amygdaloids of the Cupriferous of the northern part of the state.

12. Below this the drill entered a compact red felsyte, the drillings from which, while showing some of the soft red rock described above, also become sub-granular and phanero-crystalline, the separated minerals being apparently orthoclase and a greenish foliated mineral like some chlorite. In this the work stopped at the depth of one thousand feet.†

* Compare the sixteenth annual report.

† Subsequently the official record of this well was furnished by Mr. S. R. Patterson, of Hartford City, Ind. But this is confirmed by no samples of the drillings. It fills up some of the gaps of the other record, and confirms the depth reported for the red quartzyte, here-

The record of this well seems to indicate that the Cupriferous formation lies below not only the Potsdam quartzyte, or some portion of it, but also below some portion of the Animike, at least below some beds which are identifiable with the magnetitic, fine quartzytes of the Animike. This brings up various important stratigraphic problems which have been studied in the northern part of the state, but their consideration cannot be entered on here.

The deep well at Stillwater. The well at Stillwater was drilled, not with direct reference to seeking burning-gas, but, while the prevalent agitation on that subject probably prompted the undertaking, several citizens united in an effort to ascertain thoroughly the nature of the rocks that might lie below the city to the depth of two or three thousand feet. The well is 5 5-8 inches in diameter. It is situated on block 21, of the original town, about 40 rods west from the City Hall. In the following record the figures show the bottom of the respective strata, but the samples are from the top of the same, having been collected when the several changes first took place. The pipe rests on the stratum represented by the sample got at 701 feet. The hole is dry, nearly, below this pipe, except that by seepage a small quantity of brine enters the well. After stopping eight days there was found in the bottom about eight feet of such brine. This is on the authority of Mr. John McKusick. Some of this was preservedand on being examined by Mr. Sidener at the University laboratory was found to embrace some bromine, this test being made to ascertain its alliance with natural rather than artificial salt water.

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styled "conglomerated granite." The red slate of this record (No. 11) is the same as No. 11 of the record above. But No. 12, the "dark blue granite," is the same as No. 10, the actual order of succession being more likely that of this record.

1.	Soil	10 feet.
2.	Quicksand and gravel	78 feet.
3.	Soft sandstone	28 feet.
4.	Red rock	10 feet.
5.	Sandstone	100 feet.
6.	Slate	100 feet.
7.	Sand rock	100 feet.
8.	Green slate	70 feet.
9.	Soft sand or water rock	84 feet.
10.	Conglomerated granite	150 feet.
11.	Red slate	100 feet.
12.	Dark blue granite	75 feet.
13.	Red slate	25 feet.
14.	Red granite	70–95 feet.

Record of the Stillwater well.

		Taken at
1.	Rusted, coarse quartz sand, rounded	18 feet.
2.	Gray siliceous shale, or "slate."	103 feet.
3.	White sand, with some yellowish shale	112 feet.
4	Fine white sand, giving first water	162 feet.
5.	Green shale	203 feet.
6.	Fine white sand, with globules of pyrites	215 feet.
7.	Green shale or sand, mingled with some white sand	271 feet
8.	White sand with some specks of green sand; water in large volume	302 feet.
9.	Mainly white sand, having a grayish aspect	312 feet.
10.	Quartz sand, with some gray grains, all rounded	322 feet.
11.	Rounded white sand, with some gray grains and some pyrites	349 feet.
12.	Gray shale, slightly greenish	380 feet.
13.	Whitish sand, but specked with pink, gray and some yellowish quartz, and occasionally a red orthoclase fragment	450 feet.
14.	White sand, rounded	460 feet.
15.	A greenish-whitish, compact, kaolinic shale or clay, with a considerable amount of rounded quartz sand, the last probably mixed in the clay by the drilling process	540 feet.
16.	Coarse, yellowish-white quartz sand, almost pebbly	630 feet.
17.	The same. Here the water all ran out	680 feet.
18.	Red slate, or shale, with white kaolinic grains	701 feet.
19.	White sand (quartz) mingled with reddish grains and with red shale pieces	706 feet.
20.	Red clay (shale), unwashed, hardened in drying	717 feet.
21.	Dark-red or brown feldspathic sandstone	796 feet.
22.	Dark-red or brown feldspathic sandrock	892 feet.
23.	Somewhat darker, otherwise the same as the last	923 feet.
24.	Same as the last	952 feet.
25.	Same as the last	2250 feet.

At the time this depth was reached (Dec. 6, 1888), there was a temporary suspension of work, but it was resumed again subsequently, the record being reported at 2,570 feet to be still the same as at 2,250 feet. This gradually became more kaolinic-feldspathic and trappose, also amygdaloidal and calcitic, and at 3,300 feet was succeeded by diabase and a succession of beds characteristic of the Keweenawan to 3,400 feet.

This red, or brownish rock (No. 25), is quite a different rock from the red kaolinic rock described in the Minneopa well, and lies much higher in the strata. This is the Fond du Lac and Ashland brown sandstones, well known as a building material, with the interstratified shales, a section of which on the St. Louis river has been taken with care and published in the tenth report of the survey.* There seems to be in this well an alternating graduation

* Tenth report p. 30. The full thickness is not represented in this section.

from the light-colored sandstones to this feldspathic and reddish formation, indicating a chronological downward order unbroken by any important omission of strata, or unconformity. This agrees with observations in other places, and in some other wells; and if the "ash-bed" reddish rock described in the Minneopa well be correctly placed in the strata above the Animike, or within the Animike, there must be between this "red rock" and that of the Minneopa well, not only the red quartzyte but also the gabbro horizon. The gabbro sheet, therefore, if it extended to Stillwater, would be the first of the crystalline rocks that might be expected in further prosecution of that well. Below that would come, in regular order, the New Ulm quartzyte; then the Animike black slates with their magnetite and felsyte.*

The deep well at Moorhead. All information respecting this well was obtained through the courtesy of Mr. Sam. Partridge, of Moorhead. He has furnished a complete set of the drillings, and some notes that were made as the work progressed, by Mr. Andrew Holes. These notes are included at proper places, in the following record, which is made up from the drillings sent. The contract was executed by Gray Brothers, of Jamestown, Dakota. The well is located at centre of 7th street, north of Front street. Contractors began with a 14 in. hole, for 100 feet. Water was struck at 120 feet, which rose to near the top. Owing to losing the drill at about 174 feet in quicksand, and being unable to raise it, the contractors commenced at another point about 30 feet north of the first hole. A boulder was struck at 150 feet, and another at 170 feet, in gravel; broken by blasting.

		Thickness.	Depth of Well.
1.	Black soil	2 feet.	2 feet.
2.	Yellow loam, or clay	3 feet.	5 feet.
3.	Yellow clay — lacustrine or alluvial; brick clay	50 feet.	55 feet.
4.	Very fine, lacustrine blue clay, with occasionally a pebble	55 feet.	110 feet.
5.	Drift gravel, with some clay, blue	5 feet.	115 feet.
6.	Drift gravel, much limestone	10 feet.	125 feet.
7.	Coarse drift gravel, much limestone	10 feet.	135 feet.
8.	Drift gravel and sand, somewhat clayey; blue	10 feet.	145 feet.
9.	Sandy and gravelly clay, blue	10 feet.	155 feet.
10.	Sandy clay, blue	10 feet.	165 feet.

* At a depth of 3,500 feet (May, 1889) the drillings indicate that the drill has entered gabbro, though of rather finer grain than most of that which appears in the hills of the Mesabi range, north and east of Duluth.

11.	Sandy clay, blue	20 feet.	185 feet.
12.	Gravelly and sandy clay, blue; with flakes of metallic iron, probably from the drill	10 feet.	195 feet.
13.	Boulder; hard gray gneiss, mostly feldspar and quartz, fine-grained, the sparse mica being silvery and like hydromica, evidently a metamorphic rock, striped with sedimentary variations, some of the feldspar pinkish; broken by dynamite	5 feet.	200 feet.
14.	Boulder; quartzose, gray, evidently fragmental, very hard, in a talcose or sericitic matrix, and with veins of the same	20 feet.	220 feet.
15.	Bluish, sandy clay	20 feet.	240 feet.
16.	Bluish, sandy clay	60 feet.	300 feet.
17.	Quicksand	45 feet.	345 feet.
18.	Quicksand, with some clay	15 feet.	360 feet.
19.	Green shale or clay; the drillings contain some grit; evidently the commencement of the green granitoid rock	15 feet.?	375 feet.
20.	No drillings sent	15 feet.	390 feet.
21.	Soft, reddish, feldspathic chlorite-granite, or gneiss	10 feet.	400 feet.
22.	No drillings sent	40 feet.	440 feet.
23.	Soft, reddish, feldspathic chlorite-granite, or gneiss	35 feet.	475 feet.
24.	Soft, reddish, feldspathic chlorite-granite, or gneiss	125 feet.	600 feet.
25.	Soft, reddish, feldspathic chlorite-granite, or gneiss	35 feet.	635 feet.

[NOTE.—The rock from 375 feet to 635 feet is said to vary from "blue" (green?) to red, or brown, and *vice versa*, every 20 or 30 feet, indicating a gneissoid rock.

26.	Same as the last	110 feet.	745 feet.
27.	The same, but varying toward the rock like the boulder described above at the depth of 200 feet	20 feet.	765 feet.
28.	Same as the last, but more green from chlorite	35 feet.	800 feet.
29.	Same as the last	100 feet.	900 feet.
30.	The same	100 feet.	1000 feet.
31.	The same; but the drillings present a different aspect, and are so fine that only with difficulty can the ingredients be made out. The feldspar and quartz are not perfectly differentiated	10 feet.	1010 feet.
32.	The same as the last, but coarser. It is evident from this that the rock is an imperfectly crystalline granitoid rock, the outlines of the quartz and feldspar not being defined, but blending together, as if a finely granular felsyte, with some cloudings due to impurities. The impurities cannot be easily defined mineralogically, as they also fade out in the mass, but are perhaps micaceous or chloritic	40 feet.	1050 feet.
33.	The same, but darker colored; the feldspathic ingredient is frequently pink	15 feet.	1065 feet.
34.	The same; fine drillings	25 feet.	1090 feet.
35.	The same; fine drillings	30 feet.	1120 feet.

36. Soft, greenish, but finely red-mottled, flaky felsyte(?); texture and grain like the last. This is so fissile and so dark colored that it has a very different aspect from the last. The partings are glistening as if slickensided and chloritic. It is associated with some of the eruptives, but its characters do not identify it certainly with any known horizon...	75 feet.	1195 feet.
37. The same, with some calcite and some white feldspar(?)..	10 feet.	1205 feet.

The Moorhead well shows that there the drift rests on crystalline rocks of a peculiar gneissoid kind.

[*Note.* As the Moorhead well is being drilled at public cost, the writer deemed it proper to remonstrate against further expense, and communicated at once with the mayor through Mr. Sam. Partridge. In a few days the *Moorhead News* contained the following, giving correctly the recommendation written to the mayor:

Mr. Sam. Partridge this morning received a communication dated May 8, from Prof. N. H. Winchell, state geologist, addressed within to the mayor of Moorhead, stating that he had just examined the samples of drillings taken from the Moorhead artesian well which were sent to him a short time ago, and expressing regret that he had not before been able to obtain samples, "because," said he, "I could at once have told you that there was no earthly use of your going to further expense on the well. You ought to have stopped when the drill struck the rock at the depth of 390 feet, the rock being granitic and of that sort which forbids any hope of obtaining artesian water or other product of value."

Soon thereafter further drillings were sent by Mr. Partridge, and by other gentlemen, asking re-examination, on the ground that, "having gone so far it was heart-rending to give it up now." The lower drillings did not afford any reason to change the opinion before reported.

Still the drill was continued, and the newspapers of Fargo (*Argus*) spurred it on with such comments as follows:

Mayor Hansen, of Moorhead, says they intend to continue sinking the artesian well, in spite of professor Winchell's prognostications. And in this the whole Red River valley says — "good for Hansen." There is no geological or other prescience that can guess dead sure on Red River valley matters. Success is what is wanted, and Hansen shows true grit.

When the Findlay, Ohio, people were first boring for gas, the state geologist delivered a lecture there in which he said it was useless to bore in such a formation, as they would never find gas. But they kept right on and struck a gas

well — before the state geologist got away from town. And now Findlay has the biggest gas display in the world. With all due respect to Mr. Winchell, state geologist of Minnesota, why not let Moorhead do the same?

A second letter from Mr. Partridge, accompanied by drillings down to 1,425 feet, states that a remarkable change occurred after the last drillings before were sent, viz.: *A bed of quick-sand had been found near the bottom of the well, from which water quickly rose to near the top of the ground*, and that the interested parties felt greatly encouraged to proceed.

On examining the samples from this lower depth, they are found to be as follows, when thoroughly washed:

38. Mainly water-worn sand, but embracing also films of iron rust, scales of slag from some furnace, or fire-box where coal was burned, angular bright pieces of soft coal which burns readily in a flame, and some seeds which look fresh enough to sprout. These have been planted in order to ascertain, if possible, what sort of angiospermous vegetation lived at the age of the Moorhead granite and has so singularly preserved not only its form but its farinaceous store of food so long. There are also in this some granite drillings. This sample was sent in the condition of a hardened clayey lump, but on washing away the finer parts these ingredients appear. It is probably from this that rose the supply of water which came to near the surface,—though it is a reasonable query as to how it was distinguished from that which was struck at 120 feet and which rose then to near the top	15 feet.	1265 feet.
39. Mixed granitic rock; some rounded material, including pebbles of weathered limestone that effervesce in hydrochloric acid; also scales of irony matter from some clinkers from coal burnt in a furnace or other fire-box	15 feet.	1280 feet.
40. The drillings are mainly of a light-colored but chloritic granite, quite rusty with scales of iron from the drill, and others from some other source as remarkable as those mentioned above	45 feet.	1325 feet.
41. Drillings mostly of white feldspar and quartz, but also with evident, fresh chlorite-films	100 feet.	1425 feet.

It is scarcely necessary to comment on these drillings. They demonstrate, to any geologist, not only the position of the bottom of the well, and the futility of further expense, but also the probably intentional tampering with the record, by which it was hoped the enterprise would be pushed further.

According to the latest accounts the mayor of Moorhead is still drilling in this granite. May 26, 1889.]

The Duluth deep well.

The drillings of this well, as furnished by Messrs. Gridley, Mishler and others, were procured and sent to the survey by Wm. F. Phelps, Esq., secretary of the Duluth chamber of commerce. They are well washed and carefully preserved in glass bottles and numbered so as to show the different depths from which they came. After the well had been sunk about 231 feet the enterprise changed hands. Previous to 231 feet no record was kept, nor drillings preserved. The well is located at Short Line Park, near Duluth, which is a short distance west of the head of lake Superior, but within the general valley of the St. Louis river. The mineral water met with in this well was analyzed by Prof. Dodge, of the university of Minnesota, and the result of the analysis is given below. It seems to be very similar to the brine met with in the Stillwater and Hastings wells.

	Record.	Thickness.	Depth of Well.
1.	Earth	100 feet.	100 feet.
2.	Rock (?) no drillings preserved	131 feet.	231 feet.
3.	Brownish-red, finely granular, homogeneous, with little free silica, apparently of the copper series	12 feet.	243 feet.
4.	Gray epidotic, finely granular gabbro	33 feet.	276 feet.
5.	No drillings	104 feet.	280 feet.
6.	The same as No. 4	37 feet.	417 feet.
7.	The same as No. 4	31 feet.	448 feet.
8.	Apparently the same, but finer-grained, approaching diabase	15 feet.	463 feet.
9.	Essentially quartzose, but the drillings contain also evidently feldspathic (labradoritic) fragments; the grains vary from limpid quartz to gray or pink or purplish; some of the larger are composed of grit, the included grains being rounded	5 feet.	468 feet.
10.	The same as the last, pyritiferous, a quartz conglomerate	5 feet.	473 feet.
11.	Drillings gray, pulverulent; rock very fine-grained, aphanitic, apparently soft	17 feet.	490 feet.
12.	Drillings brown, with green grains of epidote (?) white grains of calcite and quartz and red grains of orthoclastic material. The needle does not pick out grains that are plainly of magnetite, but scales of rusted metallic iron, derived from the drill. This iron is found also in all the foregoing. The rock is not typical gabbro, but represents one of its modifications. It is rather fine-grained	16 feet.	506 feet.

13. This rock is essentially a brown felsyte perhaps a conglomerate, some parts being finely granitic in grain. It is also apparently fragmental, and also resembles some of the coarser, pseud-amygdaloidal beds of the Cupriferous seen along the lake Superior shore further east	2 feet.	508 feet.
14. Evidently a conglomerate that contains principally brown felsyte; also brown shale, and white and gray quartz and granular quartzyte. The shale is perhaps the matrix, and has mainly disappeared in the process of drilling and washing the drillings. It is slightly pyritiferous, and epidotic	3 feet.	511 feet.
15. Pink and gray, quartzose conglomerate, and granular quartzyte, pyritiferous	2 feet.	513 feet
16. The drillings are principally granular white or limpid quartz in small, angular grains. The cement seems to have been of the same material in finer grains	1 foot.	514 feet.
17. Same as the last, evidently a white, granular quartzyte	2 feet.	516 feet.
18. The same, but showing gray also	4 feet.	520 feet.
19. The same, but more gray, also pink	4 feet.	524 feet.
20. The same	4 feet.	528 feet.
21. Drillings dark-gray, pulverulent; similar to No. 11 above	2 feet.	530 feet.
22. Trap-rock, epidotic diabase, some fragments brown; drillings fine, generally of a gray color	24 feet.	554 feet.
23. Gray, diabasic traprock, epidotic and apparently amygdaloidal	20 feet.	574 feet.
24. The same; some fragments being brownish	16 feet.	590 feet.
25. Drillings very fine, but apparently the same as the last	8 feet.	598 feet.
26. Brown-gray diabasic rock, rather coarse-grained	15 feet.	613 feet.
27. Drillings are of two sorts, (a) brown granito-felsitic, and (b) gray, fine-grained and traplike; some of the latter appearing to be porous or amygdaloidal or fragmental	6 feet.	619 feet.
28. "Black slate" or argillyte, aphanitic and purplish-gray, occasionally embracing fragments of coarser grit-rock as well as of light-grain softer slate or schist. This black slate has a slaty cleavage, but it can not be determined whether coincident with a sedimentary bedding or not, although it appears to be independent of such a structure; evidently the Thompson slate formation	61 feet.	680 feet.
29. The same as the last; with some drillings of white vein-quartz	200 feet.	880 feet.
30. The same, but having a greenish tinge apparent, and being some softer	200 feet.	1080 feet.

31.	No drillings	90 feet.	1170 feet.
32.	The same as No. 28	5 feet.	1175 feet.
33.	The same as No. 30	60 feet.	1235 feet.
34.	Essentially the same rock, but apparently not so slaty, with vein quartz	105 feet.	1340 feet.
35.	The same, rather light gray	30 feet.	1370 feet.
36.	Gray slate, slightly pyritiferous; evident slaty cleavage	5 feet.	1375 feet.
37.	The same as the last	25 feet.	1400 feet.
38.	Drillings are of two kinds, (1) dark gray slate (?) like the last, and (2) a lighter rock, apparently hydro-micaceous slate	35 feet.	1435 feet.
39.	Drillings very fine and of a light yellowish color. Thorough washing leaves a residue of fine quartz grains mainly; but this does not indicate the general character of the rock, as the matrix of these grains is evidently lost by the washing. These grains are mainly white, sometimes glassy, but of various shapes and sizes. They can not be said to be waterworn, and are themselves minutely granular when magnified about 40 diameters. Mingled sparsely with the white and glassy grains are also a few that are purplish, or gray, and also some of a loose, hypermicaceous schist. The general yellow-rusty color is caused probably by the oxidation of iron scales derived from the drill. These scales pervade all these drillings	2 feet.	1437 feet.
40.	The same as the last	8 feet.	1445 feet.
41.	The same as the last. In this can be seen, under the microscope, some fragments of a rock that appears to be a kaolinic itacolumyte, and it is not unlikely that they are from the rock that furnishes these quartzose washings	3 feet.	1448 feet.
42.	The same as the last, but also contains some drillings like the next	2 feet.	1450 feet.
43.	Gray compact, very fine-grained, crypto-crystalline or fragmental, diabasic (?) rock.	2 feet.	1452 feet.
44.	Same as the last, but also comtains some gray slate..	2 feet.	1454 feet.
45.	Same as No. 43	1 foot.	1455 feet.
46.	The same fine-grained gray rock predominates; under the microscope it appears to consist of fine glittering grains resembling quartz	1 foot.	1456 feet.
47.	Same as the last, but more evidently a fragmental gray quartzyte	1 foot.	1457 feet.
48.	The same, but somewhat lighter-colored	10 feet.	1467 feet.
49.	Same as the last	10 feet.	1477 feet.
50.	Gray quartzyte, very fine, same as No. 46	10 feet.	1487 feet.
51.	The same	8 feet.	1495 feet.

52.	The same, but some grains are apparently from a somewhat cleavable rock, though not argillitic......	5 feet.	1500 feet.
53.	The same gray rock, evidently slaty and finer-grained	7½ feet.	1507½ feet.

Summary of the Duluth well.

It appears from the above record that the Duluth well passed through 131 feet of drift materials. It encountered the fragmental rocks of the Cupriferous and found 112 ft. of characteristic strata. It then entered gabbro at 243 ft. which was found to be 220 feet in thickness, extending to 463 feet. Then came a hard red and purplish quarzyte. This is interbedded with imperfectly characterized gabbro, with conglomerates consisting largely of brown felsyte pebbles, and with soft, indeterminable rock the drillings of which are very fine or pulverulent, of a dark gray color; the thickness of all the layers (67 ft.) carrying the well down to 530 feet. At the depth of 530 ft. the well entered trap-rock. As this is below the foregoing gabbro it introduces a new element in the stratigraphy of the Cupriferous, the gabbro having been regarded as the lowest of the Cupriferous. This trap, with its associated amygdaloidal beds, some known felsytes (some of them granitic), and fragmental tuffs, continued to the depth of 619 feet, a thickness of 89 feet, when the black slates of the Animike were struck. These slates, with the gray quartzytes, and occasional diabasic rocks connected with them, have continued thence to the bottom of the well at 1507½ feet. In this formation, at the depth of 1225 feet the operators report the discovery of the mineral water referred to below. But it is quite likely that it was in the drill-hole all the time after passing the Cupriferous formation. Such water was found in the Stillwater well and also in that at Hastings in the Cupriferous, but the mineral contents of that at Duluth are not only more varied but also in far greater amount. Following is the analyses of both. The report of the Duluth analysis was furnished with the drillings, and that from Hastings was analyzed in 1881 at the request of Prof. C. W. Hall.

Analysis of water from the Duluth deep well.

An analysis of water taken from the gas well at Short Line Park, near Duluth, made by professor James A. Dodge, of the State University of Minnesota, at the request of Dr. D. A. Strickler, of Duluth, Minn.

	Part per million.	Grains per gallon, U.S.
Siliceous matter	200.9	11.718
Carbonate of iron	44.6	2.601
Sulphate of magnesia	2.0	.117
Chloride of magnesium	503.0	29.340
Chloride of calcium	16,847.0	982.685
Chloride of sodium	15,070.0	879.046
Chloride of potassium	500.0	29.165
Bromide of sodium	430.0	25.069
Lithium salts	traces.	traces.
Total mineral matter	33,597.5	1,959.741
Free ammonia		.93
Albuminoid ammonia		.40

Analysis of the water from the flowing well at Hastings, reported by Prof. Dodge.

The following gives the character of the solid residue from the water. Compare Vol. II, of the final report (Dakota county) for an account of this well:

	Grains per gallon.
Silica	.62
Carb. lime	9.29
" iron	.17
Sulph. mag	5.84
Chl. mag	1.82
Chl. potass	1.15
Chl. sod	26.15
Total solid matter	45.04

The deep well at Faribault. The record of this well could not be obtained. No drillings were preserved. It was reported to be 520 feet in depth, "with signs of gas and anthracite coal."

The deep well near the State Fair grounds, between St. Paul and Minneapolis, in which also the "expert" from Pennsylvania predicted and subsequently "discovered" burning gas, is said to be 500 feet deep. Of this well the record could not be obtained.

The well in North St. Paul, in like manner can not be reported, since the record is unknown.

The deep well in South St Paul, drilled by the same parties as the last two, under the instigation and advice of the Pennsylvania "expert," will also go to posterity with no record except as a monument to the infatuation which can be inspired by the positive assertions of a wanton adventurer in the minds of men ignorant of geology but eager for wealth.

In the matter of the drilling of these four wells last mentioned,

all of which have now been abandoned, the advice of the writer was sought, and he unhesitatingly recommended that no money be spent in a search for gas. This opinion was based on the geological structure of this part of the state and the known geological relations of the gas-flowing wells of other states.

CONCLUSIONS.

The experience which has resulted from the efforts to find natural burning-gas in Minnesota, as above detailed, gives rise to some reflections and conclusions which it will be well to gather into a final statement.

1. There is a body of geological truth that to the geologist is as inflexible as any natural law, and as sure as any deduction from observed facts. This truth is accepted by all geologists, without exception. When any economic research or any scientific question is presented for solution it must first be compared with these known laws of geology. If it violates none of them the geologist gives his answer accordingly, for these truths are not fluctuating. His answer must be in accord with the facts, and the evidence so far as it exists. If the problem involves elements which lie beyond the scope of the facts in hand, or which are not covered by any established law of the science, his answer must necessarily be *that he does not know.* He may, however, go beyond a statement of ignorance. He may collate the evidence favorable or unfavorable bearing on a hypothetical answer.

2. It is in the realm of this uncertainty that lie most of the problems that the geologist has to answer; and it is here that he sometimes makes the mistake of giving a conclusive answer when he should give a conditional one. A similar mistake is made by some scholastics and so-called philosophers in estimating the value of geological evidence in general. This error is due to a confounding of geological science with geological hypothesis. There is no limit to geological hypothesis, and any bungler or itinerant "expert" may indulge in it; but there is a distinct boundary to the body of truth known as geological science. Sometimes the popular estimate is based on the shifting arena of hypothesis, and geology is charged with being a mass of speculation and contradiction, liable to vary from year to year. The practical geologist, in answering economic problems, has to discriminate rigidly between science and hypothesis, and to adhere unflinchingly to the guidance of science.

3. If under the guidance of science, the geologist states that

neither the Trenton limestone nor the Coal Measures can be found by drilling in a region where the surface rock is the St. Peter sandstone or the Shakopee limestone, he is justified by one of the laws of his science. If further he be asked if there be gas beneath the St. Peter sandstone, his "body of truth" does not give an infallible guide and will not answer positively. It will only answer conditionally. The geologist here can only appeal to such evidence as exists, and can answer, after weighing it *pro* and *con*, by a statement of probability on the side of the preponderance of evidence.

4. It requires but a brief examination of the reports that have been published of the geology of the state to learn that the great formations that furnish gas in the United States are almost wholly wanting in Minnesota; the Trenton only being found in such situation as to give a reason for exploration.

5. The results of all wells that have been sunk in the state, with a primary or remote idea of discovering gas, have confirmed this statement, and have coincided, except in minor matters of detail, with the conclusions that have been expressed and with the published geological maps and reports of the survey.

6. The facts stated in the reports, therefore, may be considered as belonging to the "body of truth" of the science, and can be relied on for future guidance so far as they bear on this economic question.

7. The drilled well at Freeborn has passed through the Trenton limestone, and hence through the lowest known formation that supplies burning gas; and if gas exists, as asserted by the superintendent, in the St. Peter sandstone that lies below the Trenton and is now only repressed by the surrounding and overlying volume of water, it will be, if demonstrated by the efforts that are now being made, a great discovery in the geological environments of the gas problem. It may, hence, become as important as the original discovery of gas in the Trenton limestone at Findlay, and thus add another formation to the list of gas producers.

7. This, however, will require an actual demonstration to be admitted into the "body of truth" of geological science, since the science at present, so far as it has any evidence, pronounces with a strong preponderance of weight against it.

8. So far as the science affords any evidence in favor of gas below the Trenton limestone in Minnesota, it may be summed up about as follows, applying it to the region of Freeborn: There is, perhaps, one chance in ten that the formation which is known

in the northern part of the state as *Animike slates and quartzytes*, underlies the county of Freeborn at the depth of about 3,000 feet. In case it were found at that depth there might be, perhaps, one chance in one hundred that it would contain some gas, and one in a thousand that it would afford enough for economic purposes.

THE ACTUALITY AND POSSIBLE SOURCE OF THE GAS AT FREEBORN.

The fact still remains that natural burning-gas is found at Freeborn. It rises from a sandy layer in the drift, about seventy-five feet below the surface, and burns freely and even violently when gathered in pipes and ignited. As the drill passed through no Cretaceous strata their presence in the vicinity is rendered more questionable, but still not negatived. As the drill penetrated no vegetable deposit known elsewhere as the "forest bed" its presence is also more questionable. But both these are liable to produce gas, the latter in smaller quantities than the former, and either may exist in the neighborhood and might be struck in case of a drill at some short distance in any direction from the site of the present well. Indeed there is no source for this gas, so far as the writer is aware, except the Cretaceous, or the "forest bed," and he is inclined to refer it as heretofore to the Cretaceous.

The "forest bed" is known to exist in Freeborn county, as well as in Mower, and to extend irregularly and indefinitely southward into northern Iowa. It seems to furnish carbonic acid gas in some wells at Albert Lea, and has been the cause of some trouble in search for good water for domestic use. But it is not invariably the case that carbonic acid is produced by this bed of vegetation. Prof. Orton states that in Ohio a light carburetted hydrogen is struck in the drift deposits much more frequently than carbonic acid.*

On the other hand a well in Vernon, Blue Earth county, which gives a voluminous discharge of carbonic acid gas, owned by C. B. Frazer, is said to have a record which indicates that the gas originates in the Cretaceous. This well passed through a clay, or shale which is apparently of Cretaceous character and age, and at about 115 feet entered sand. The future must determine the source of the gas that escapes at Freeborn, for the evidence seems almost evenly divided between the Cretaceous and the "forest bed."

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*Report of the Geological Survey of Ohio, Vol. 41, p. 773.